LABORATORY EXPERIMENTS

IN

FUNCTIONAL CHEMISTRY

By

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TO THE TEACHER

IT has long been known that the laboratory is the greatest agency available for the teaching of science. When it performs its true educational functions, the laboratory aids in training the pupil to be neat, cleanly, honest, truthful, and to respect the rights of others. It teaches him to be open minded, self-reliant, and alert in seeking the relations between cause and effect. It aids in the development of the knowledge of how to study, in the training of self-directed work, and in the development of initiative. It aids in the mastery of facts and the development of the ability to test these facts, to arrange them in many different patterns and to draw logical conclusions from them. This is the scientific method of problem solving. It not only lays a sturdy foundation for successful work in chemistry, but carries over into life those thought habits which are of such vital importance to an intelligent reaction to our everyday problems.

Experienced teachers know the desirability of a close teacher checkup of the work done in the laboratory to prevent this most useful phase of science instruction from degenerating into a meaningless jumble of seemingly unrelated and irrelevant procedures and manipulations. The experiments in this book were designed to bring about the attainment of the "outcomes" of instruction in chemistry mentioned above, and to afford a means by which laboratory work may be checked effectively and with a minimum expenditure of time. The experiments as a whole are constructed so as to facilitate the mastery of classroom material to such an extent that the time required in the classroom may be materially shortened. The experiments themselves are so concisely and clearly stated that they are self-directional. They are truly learning exercises.

At the beginning of each experiment, a short introduction gives the student a brief view of the experiment as a whole and aids in his understanding the object of his work. A picture of the apparatus set-up is given in each experiment, which can be read at a glance, thus saving the student's time. The procedures are given in short, specific directions, thus avoiding ambiguity and the possibility of confusion. You will observe that there are no spaces to fill in on the first page of the experiment. This is a time saving device, and also serves to focus the attention of the student upon the work he is doing, rather than upon finding an answer to write down.

If questions and answers were eliminated altogether, many of the students would become careless and dilatory in their work. So, since a means of supervision is necessary, all the questions and written work are placed on the second page of the experiment. This serves two purposes. First, it permits the student to perform the experiment without interruption, and then to write it up as a whole during the

latter part of the period. At this time, he is led to review the experiment mentally and to search for the cause and effect of everything he has done. Second, the highly objective questions may be quickly and accurately graded by the use of a key. This is very important because it affords the teacher an accurate check on each student at the close of each laboratory period. This permits him to correct any bad practices which the student may have slipped into before they have had time to become habits. Then again, the accurate grading of the experiments adds an extra incentive in the form of an immediate reward for work well done.

There is no "best" procedure for the conduct of the chemistry course, but it is suggested that the teacher at least try the following procedure:

A. 1 or 2 DAYS. Return the corrected tests on the preceding topic for a thorough discussion in order that the students may benefit from their mistakes. Then collect the tests and file them away for possible future reference. Give a superficial explanation and discussion of the new topic, lingering particularly upon the more difficult sections. After this, make the experiment assignments for the topic.

B. 2 or 3 DAYS. During the time spent in the laboratory, leave the students as much on their own as possible, being sure to maintain a good working discipline. Collect the experiments at the close of each laboratory period. This tends to prevent dilly-dallying in the laboratory and serves as an incentive for students to study the experiment before coming to class.

C. 1 or 2 DAYS. Return the corrected experiments and discuss each one with the class, and answer all questions. Follow this by a thorough discussion of the topic, showing the interrelation of textbook and laboratory work. In this role the teacher becomes a real instructor rather than merely an interrogator.

D. 1 DAY. Instructional test, preferably of the objective type.

TO THE STUDENT

These experiments, which you will perform in the laboratory, should add greatly to your enjoyment of chemistry and at the same time teach you many of the most fundamental facts of this most important science. Chemistry is vital in our everyday life. Chemical processes are constantly taking place all about us. Our food grows, is digested by our bodies, and is built into our own protoplasm as a result of chemical processes. There is hardly a single thing that you could touch that did not come into its present form as a result of chemical processes having taken place at some stage of its development. Therefore a thorough knowledge and understanding of the scientific facts and principles studied in this chemistry course will unquestionably add greatly to your ability to appreciate and to get the utmost enjoyment from your surroundings.

Chemistry is different from any course that you have ever studied, and for this reason you will have to study it by a different method if you would have success with the least amount of effort. The study of chemistry is similar, in one respect at least, to the study of a foreign language. You know that you must learn the vocabulary each day or you will soon be hopelessly outdistanced by the class. Chemistry is like this, for the new terms, laws and principles which you should learn on one particular day are used throughout the remainder of the course, and if you have missed this particular day's work you cannot understand the remainder of the course until you have gone back and learned the part that you missed. You cannot cram in chemistry and hope for satisfactory results.

Remember that you can never get more from a course than you put into it. Begin your study of chemistry with a real eagerness to learn. Work carefully, systematically, thoughtfully, and honestly and you will be rewarded by an enjoyment of this course which even exceeds your own expectations at this very moment. Be cautious. Some of the chemicals are poisonous, some are inflammable, some burn the skin and clothing, some are explosive under certain conditions, and there are many which cannot be mixed with safety. But, there is absolutely no danger if you follow directions carefully and refrain from mixing your own concoctions just to see what will happen. The following suggestions will aid you in being a delight to yourself, to your teacher, and to your parents.

SUGGESTIONS FOR LABORATORY CONDUCT

1. Do not smell at the mouth of reagent bottles. The fumes may be poisonous.
2. You should study to understand the meaning and purpose of each experiment before coming to the laboratory.
3. Do not waste chemicals. Use exact amounts of reagents called for in the experiment. You know that too much or too little baking powder will ruin a cake; so also, careless measurements of chemicals will give you untrustworthy results.
4. The reagent bottles are kept in alphabetical order on the shelf. After using a bottle, return it to its proper place so you will know where to find it the next time.

5. Never take the reagent bottles to your desk. Bring a suitable container to the side shelf and get the exact amount of the reagent that you need.
6. Never put left over chemicals back into the reagent bottles.
7. As you perform an experiment, observe the changes which take place, and try to understand the meaning of everything that happens. These changes may be in color, heat given off, a gas given off, or a precipitate formed.
8. In describing the results of an experiment, tell what actually happened and not what you think should have happened. If you do not trust your own results, check your suspicions by repeating the experiment more carefully or by reference to a textbook.
9. Be neat. Always put your apparatus away clean and dry. Clean the top of your desk and have your locker in order before leaving the laboratory. But, this is not an excuse for being late to your next class.
10. Put waste paper in the waste paper basket. Deposit broken glassware and solid waste chemicals in the container which is provided expressly for this purpose. Pour waste liquids in the sink and wash them out with plenty of water.
11. Never mix chemicals to see what will happen. The results might prove serious.
12. Be very careful when inserting a glass tube through the hole in a rubber stopper. A broken glass can inflict a painful cut. Before making the insertion, the end of the tube should be fire polished and both the tube and the stopper should be wet. Then grasp the tube near the fire polished end and insert it into the hole with a gentle, twisting motion.

FIRST AID FOR MINOR INJURIES

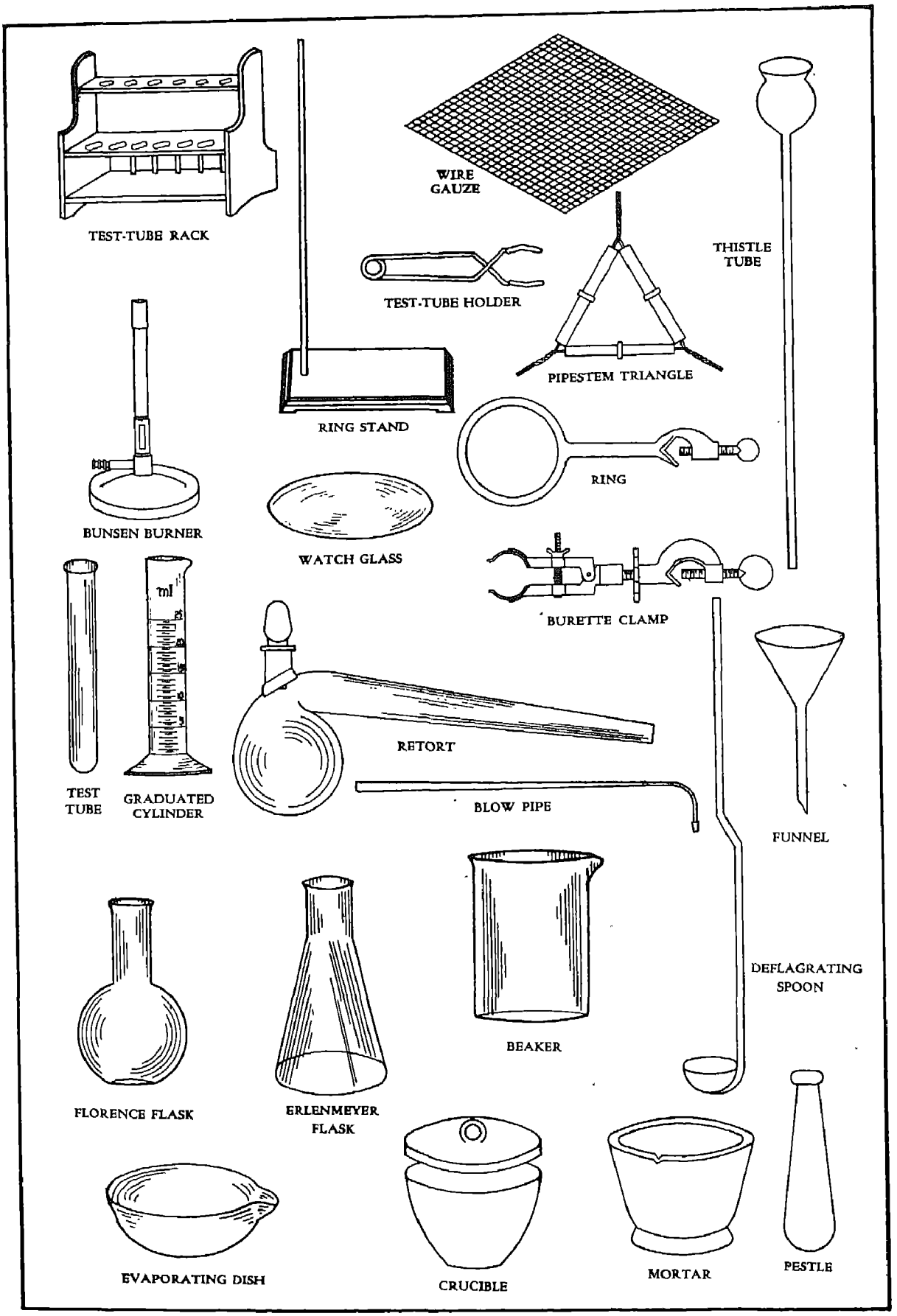
1. Report all accidents immediately to the instructor.
2. CUTS.
   Wash the cut and remove the pieces of glass with a pair of sterile forceps. Apply a drop of ferric chloride solution to check the flow of blood. Dry with a piece of sterile gauze or absorbent cotton. Apply an antiseptic such as tincture of iodine, mercurochrome, or hydrogen peroxide, and then bandage the wound.
3. BURNS.
   Cover the burned area with Unguentine, vaseline, or any other grease or oil. Bandage if necessary.
4. ACIDS.
   On The Skin.
   Wash successively with plenty of water, then with limewater, then again with water.
   On The Clothing.
   Neutralize with dilute ammonium hydroxide, and then wash with plenty of water.
5. BASES.
   On The Skin.
   Wash with plenty of water, then with boric acid solution or vinegar, then again with water.
   On The Clothing.
   Neutralize with a solution of boric acid or vinegar, and then wash with plenty of water.

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TEST-TUBE RACK
WIRE GAUZE
THISTLE TUBE
TEST-TUBE HOLDER
PIPESTEM TRIANGLE
RING STAND
RING
BUNSEN BURNER
WATCH GLASS
BURETTE CLAMP
TEST TUBE
GRADUATED CYLINDER
RETORT
BLOW PIPE
FUNNEL
DEFLAGRATING SPOON
FLORENCE FLASK
ERLENMEYER FLASK
BEAKER
EVAPORATING DISH
CRUCIBLE
MORTAR
PESTLE

Science Laboratory Regulations

The following regulations have been compiled for the safety of students receiving instruction in the science laboratories of the Los Angeles City Schools and a strict observance of the same is MANDATORY. Please read the following regulations before starting any laboratory activity.

1. Perform all experiments carefully and in such manner as to be least dangerous to all persons nearby.
2. Follow directions carefully.
3. Use small quantities of materials unless specifically directed to use large amounts.
4. Perform only those experiments specifically designated and approved by the instructor.
5. In case of ANY accident, report to the instructor at once.
6. Protect your clothes. Wear a rubber apron.
7. Be sure all containers such as test tubes, beakers, and flasks are clean before using. Material left in containers from previous experiment may cause explosions.
8. In case of burn from an acid, wash injury immediately with plenty of water, then apply gauze saturated with sodium bicarbonate solution.
9. In case of alkali burn (sodium or potassium hydroxide), wash immediately with plenty of water, then apply gauze saturated with vinegar.
10. Never heat a completely stoppered container.
11. Never point the mouth of a test tube toward your face or toward your neighbor while you are heating it.
12. Never bring gasoline, ether, carbon disulfide, alcohol or other volatile, inflammable liquids near a flame.
13. Never add water to an acid (especially sulfuric acid), but cautiously add acid to the water.
14. Never taste or drink anything in the laboratory unless specifically directed to do so.
15. *Never handle metallic sodium, potassium, red or white phosphorus. These should be used only in demonstrations by the teacher, if at all.*
16. *Never make explosive compounds or mixtures. Potassium chlorate must be used only in teacher demonstrations.*
17. Never work in the laboratory unless an instructor is present.
18. Never pass your hand or arm over a lighted burner.
19. Never use concentrated strong acids unless directed to do so by teacher. Strong acids are kept in store-rooms inaccessible to students, and given out only in the amounts required for experiment.
20. Hydrogen, acetylene, carbon monoxide, and other explosive gases must not be generated or collected in any container other than a small test tube (18 mm. x 150 mm.).
21. Poisonous gases such as chlorine, hydrogen sulphide, carbon monoxide, nitrogen peroxide, etc., must be generated in a fume hood equipped with suction draft.
22. The preparation of a supersaturated solution of sodium thiosulphate (Hypo) must be done as a teacher demonstration only.
23. Never cut or use glass tubing until you have received proper instruction from the teacher.
24. THESE REGULATIONS SUPERSEDE CONFLICTING INSTRUCTIONS IN LABORATORY MANUALS.

DATE..... PERIOD..... NAME.....

EXPERIMENT 1

ELEMENTS, COMPOUNDS, AND MIXTURES

MATERIALS: Copper; mercury; magnesium; iron filings; cupric oxide; ferric oxide; magnesium oxide; mercuric oxide; sodium chloride (salt, large crystals); silicon dioxide (sand); sucrose (sugar); pepper.

APPARATUS: 1 test tube.

The purpose of this experiment is to give you practice in scientific observation. Under "Appearance" in the table, write what you actually see, and not what you think you should see.

A. ELEMENTS.

Elements are the simplest forms of matter. They can not be broken up or divided into other substances. The names of the elements are represented by chemical abbreviations called symbols. The symbol for an element always begins with a capital letter. If the symbol contains two letters, the second one is always small. The symbol for an element never contains more than two letters.

1. Four elements are listed in the table below. You will find them on the shelf. Examine them carefully.
2. Fill in the spaces under the headings of "Symbol" and "Appearance" for these elements.

B. COMPOUNDS.

Compounds are complex forms of matter. They can be broken up or divided into other substances. The names of the compounds are represented by chemical abbreviations called formulas. The formula for a compound is composed of two or more symbols. Thus, the formula for a compound tells us, by means of symbols, the elements of which it is composed.

1. Look for the oxides (a class of compounds) of the elements which you have already examined. You will find them arranged alphabetically on the shelf.
2. Fill in the remaining spaces in the table.

	ELEMENT (Metal)			COMPOUND (Oxide)
Name	Symbol	Appearance	Formula	Appearance
Copper				
Iron				
Magnesium				
Mercury				

C. MIXTURES.

Mixtures may be composed of two or more elements, two or more compounds, or compounds and elements. The individual parts of which a mixture is composed are not combined chemically and there are physical ways of separating them. There are no abbreviations for mixtures.

1. There are four mixtures on the shelf. Examine them and fill in the spaces in the table.
2. Taste a grain of salt.
3. Add a large crystal of salt to ¼ of a test tube of water. Shake it until the salt dissolves and then taste it.

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MIXTURE	APPEARANCE
Salt and mercuric oxide	
Salt and sand	
Salt and sugar	
Salt and water	

D. OBSERVATIONS.

1. What is a symbol? . . . . . _____

2. What is a formula? . . . . . _____

3. How can you tell a symbol from a formula? . . . . . _____

4. Can you tell from the appearance of mercuric oxide that it contains mercury? Explain. . . . . _____

5. Can you tell from the appearance of a compound which elements it contains? Explain. . . _____

6. How can you tell which elements are in a compound from its formula? . . . . . _____

7. Can you tell from the appearance of a mixture of salt and mercuric oxide that it is composed of two different substances? Explain. . . . . _____

8. Can you tell from the appearance of a mixture of salt and sugar that it is composed of two different substances? Explain. . _____

9. Can you always distinguish a mixture from a compound by its appearance? Explain. . . . _____

10. Give one essential difference between a compound and a mixture. . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 2

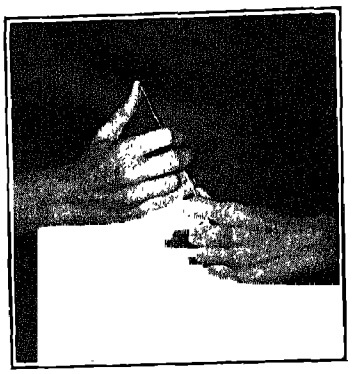
PHYSICAL CHANGE — CHEMICAL CHANGE

MATERIALS: Glass tubing, 5 cm.; copper wire, 5 cm.; magnesium ribbon, 3 cm.; mercuric oxide, ¼ teaspoon; emery paper.

APPARATUS: Burner; crucible tongs; hard-glass test tube; test-tube clamp; ring-stand.

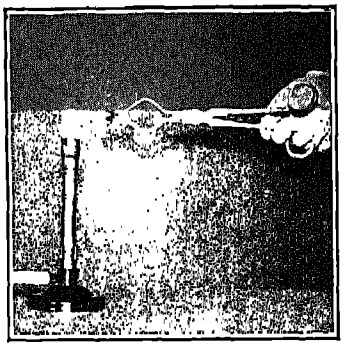
A. THE EFFECT OF HEAT ON GLASS.

1. Cautiously scrape your finger over the end of a piece of glass tubing which has just been cut.
2. Light the burner and heat the end of the tube until the flame turns yellow.
3. After it has cooled, scrape your finger over the end of the tube again and note the difference.



B. THE EFFECT OF HEAT ON COPPER.

1. Sandpaper a piece of copper wire and note its physical properties (color, luster, flexibility).
2. Grasp one end of the wire with the tongs and hold the other end in the outer cone of the flame for a minute.
3. Let the wire cool and examine it carefully.

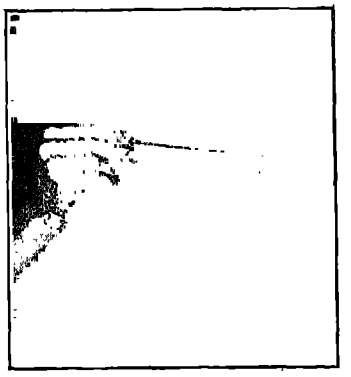


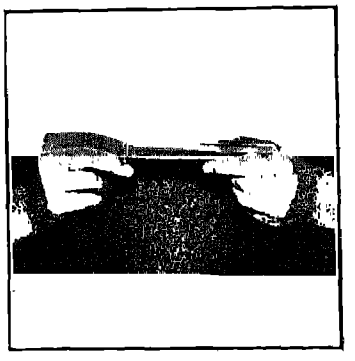
C. THE EFFECT OF HEAT ON MAGNESIUM RIBBON.

1. Sandpaper a piece of magnesium ribbon and note its physical properties.
2. Grasp one end with the tongs and thrust the other end into the flame. Note carefully everything that happens.

D. THE EFFECT OF HEAT ON MERCURIC OXIDE.

1. Cut a piece of paper about 15 cm. long and 2 cm. wide. Fold it lengthwise.
2. Grasp one end of the folded paper between the thumb and forefinger. Now place ¼ of a level teaspoon of mercuric oxide on the opposite end of the paper.
3. Carefully insert the folded paper into a test tube, held horizontally. Turn the paper over and deposit the compound on the bottom of the tube. Carefully withdraw the paper.
4. Clamp the tube at its mouth to the ring-stand, and adjust it to a horizontal position.
5. Heat the compound by moving the flame back and forth under the tube. Note carefully everything that takes place in the tube.
6. After heating the compound for about a minute, insert a glowing splint (light a splint in the flame, let it burn a moment and blow it out) into the tube and see if anything happens. Do this several times in the course of the next few minutes.
7. Observe the appearance of the new substance which collected on the sides of the tube.
8. After the tube cools, scrape some of this new substance from the sides of the tube and observe it. Note whether it is a liquid or a solid.





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E. OBSERVATIONS.

1. How did the ends of the glass feel before it was heated? . . . _____
2. How did the ends of the glass feel after it was heated? . . . . _____
3. Compare the appearance of the glass tube before and after heating. . . . . _____
4. Did the heat produce a physical or chemical change in the glass? _____
5. Give the physical properties of copper wire before heating. . _____
6. What is its appearance after heating? . . . . . _____
7. Did heat produce a physical or a chemical change in copper? . . _____
8. Give the physical properties of magnesium ribbon before heating. . . . . _____
9. What is its appearance after heating? . . . . . _____
10. Did heat produce a physical or a chemical change in magnesium? _____
11. Why was the mercuric oxide put into the tube by means of a paper trough rather than just dumped in? . . . . . _____
12. What was the first change produced in the mercuric oxide by heat? . . . . . _____
13. What happened when you inserted a glowing splint into the tube? _____
14. Was the substance which produced this effect a solid, a liquid, or a gas? . . . . . _____
15. What was the source of this new substance (where did it come from)? . . . . . _____
16. What is the appearance of the substance observed in D-7? . . _____
17. Describe the results of D-8. . . _____
18. What is the source of this substance? . . . . . _____
19. Did heat produce a physical or a chemical change in mercuric oxide? . . . . . _____
20. Give a reason for your answer in E-19. . . . . _____

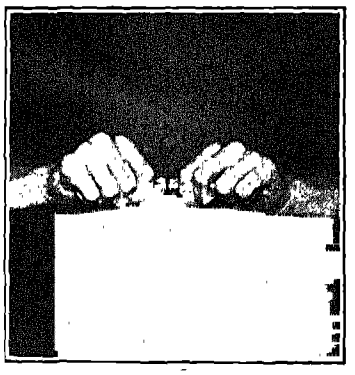
DATE..... PERIOD..... NAME.....

EXPERIMENT 3

WORKING WITH GLASS

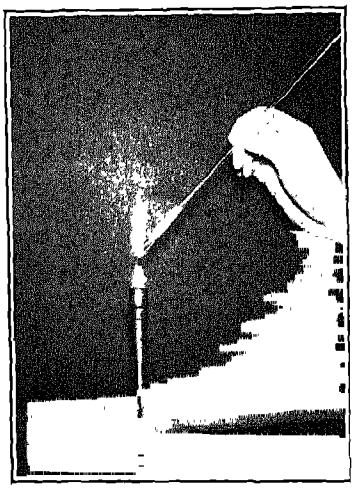
MATERIALS: 35 cm. length of glass tubing.

APPARATUS: Burner, wing-tip attachment; triangular file; hard-glass test-tube; 1-hole rubber stopper, No. 2; 30 cm. rule; 30 cm. length of rubber tubing, 3/16 inch inside diameter.



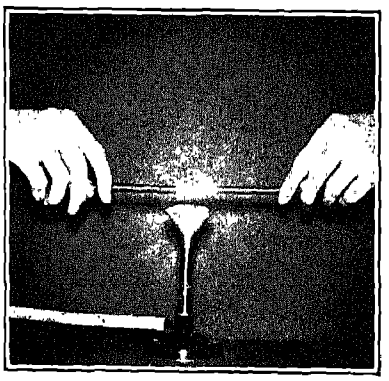
A. CUTTING.

1. Place the glass tubing flat on the desk.
2. Make a deep scratch across the tubing 15 centimeters from one end, with a triangle file.
3. Pick up the glass tube, turn the scratch away from the body, and place both thumbs close together behind the scratch.
4. Gently pull on the glass with the fingers and at the same time press with the thumbs. If the glass does not break easily, make the scratch deeper and try again.



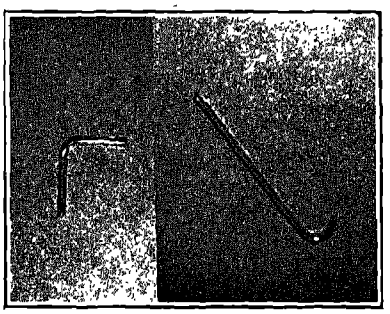
B. FIRE POLISHING.

1. Hold one end of the glass tubing, which is extremely sharp, in the hottest part of the flame.
2. Rotate the tube between the fingers so all sides will heat evenly.
3. Continue the heating until the flame becomes yellow in color, and the glass softens and the edges become rounded and smooth.
4. But, do not hold the tube in the flame too long or the size of the opening will become smaller or close entirely.
5. Fire polish each end of the two glass tubes.



C. BENDING.

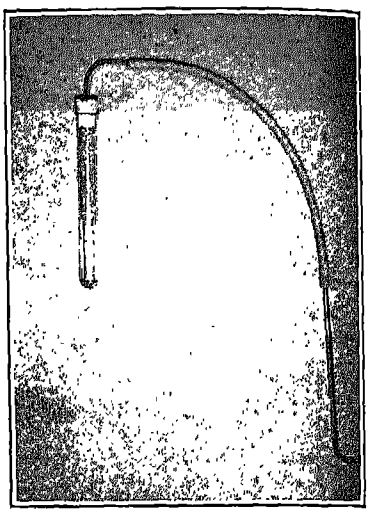
1. Place the wing-tip attachment on the burner.
2. Light the burner and adjust the gas to give a flat, blue flame about an inch in height.
3. Hold the 15 cm. length of glass tubing lengthwise in the upper part of the flame, heating it as near the center as possible.
4. Rotate the tube between the fingers so that all sides are heated evenly.
5. Continue the heating until the flame becomes an intense yellow and the glass shows a tendency to bend.
6. Remove the tube from the flame and quickly make a right angle bend, using a light, steady pressure. If it does not bend easily at first, continue the heating and try again. The "L-tube" should be a smooth curve of uniform diameter, as shown in the diagram.



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7. Make a 45 degree bend in the 20 cm. length of glass tubing, about an inch from one end. Do this by holding the end of the tube lengthwise in the wing-tip flame so the end of the tube reaches nearly to the end of the flame. Stop rotating the tube when the flame becomes an intense yellow and let it bend by its own weight. Lower the long end of the tube to make up for the bending of the glass.

D. ASSEMBLING APPARATUS



1. Wet the straight end of the glass tube, which you have just made, and insert it about half an inch into one end of the small rubber tube. Water acts as a lubricant between rubber and glass.
2. Wet one end of the L-tube and insert it into the other end of the rubber tube.
3. Wet the other end of the L-tube and press it into the rubber stopper with a twisting motion until the end extends slightly beyond the end of the stopper. This part of the apparatus is called the delivery tube.
4. Screw the rubber stopper snugly into the mouth of the hard-glass (or Pyrex) test tube. This is the generator.
5. Put the assembled apparatus into your locker. It is your generator and delivery tube for Experiment 4.

E. OBSERVATIONS.

1. When breaking a glass tube, why should you turn the scratch away from your body? . . . . . _____
2. How does the broken end of the glass tube feel? . . . . . _____
3. What is "fire polishing"? . . . _____
4. Why should the ends of glass tubes always be fire polished? . _____
5. Why should you rotate the tube in the flame when you are fire polishing or bending glass? . . _____
6. How can you tell when a glass tube is hot enough to bend? . . _____
7. Why should glass tubes be wet before they are pressed into rubber tubes or stoppers? . . . . _____
8. What kind of motion should you use when pressing a glass tube into a stopper? . . . . . _____
9. What is the name of the assembled rubber tube and the two glass tubes? . . . . . _____
10. Why should all parts of your assembled apparatus fit snugly? . _____

DATE..... PERIOD..... NAME.....

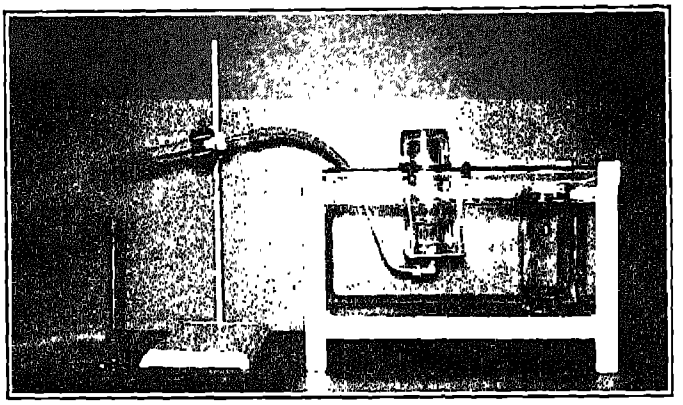
EXPERIMENT 4

OXYGEN: ITS PREPARATION AND PROPERTIES

MATERIALS: Potassium chlorate; manganese dioxide; sulfur; charcoal; magnesium ribbon; steel wool; wood splints.

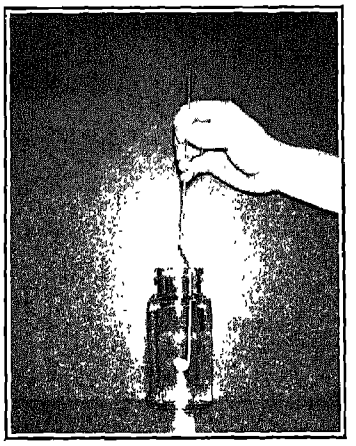
APPARATUS: Generator and delivery tube from Experiment 3; 5 wide-mouth bottles; 5 glass plates; burner; ring-stand; test-tube clamp; pneumatic trough; deflagrating spoon; forceps.

Wet the glass L-tube and insert it into the rubber stopper with a twisting motion. Place the clamp near the mouth of the test tube and assemble the apparatus as shown in the diagram. Fill the 5 wide-mouth bottles with water and invert them in the trough. Be sure that no air bubbles remain in the bottles, otherwise the oxygen which you collect will not be pure.

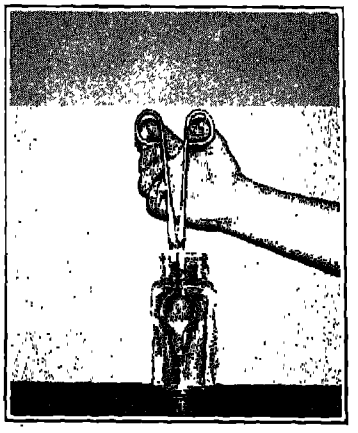


A. PREPARATION.

1. Place about 10 grams, 1 heaping teaspoon, of potassium chlorate and five grams, 1 level teaspoon, of manganese dioxide on a piece of filter paper and mix them thoroughly.
2. Pour these chemicals into the test tube. Replace the stopper and clamp the tube in an almost horizontal position. Be sure that the mixture does not touch the end of the stopper.



3. When you are ready to collect the gas, heat the mixture gently by slowly moving the flame back and forth beneath the tube. Do not let the flame come too near the end of the tube or the stopper will burn. Carefully regulate the heat so the gas will not be evolved too rapidly.
4. The first bottle of gas collected contains a mixture of air and oxygen. Discard it. Collect 5 bottles of oxygen by the displacement of water.
5. Slip glass plates over the mouth of the bottles, while still under water. Remove the bottles and place them mouth upward on the desk.
6. Immediately remove the delivery tube from the trough to prevent water from being sucked back into the hot test tube and breaking it.
7. Save the contents of the test tube for the next experiment.



B. EXPERIMENTATION.

1. Thrust a glowing splint into a bottle of oxygen as it remains mouth upward on the desk. Note the results. This is the test for oxygen.
2. Grasp a small piece of charcoal with forceps; heat it in the flame until it glows and then lower it into a bottle of oxygen.
3. Place a small lump of sulfur in a deflagrating spoon; heat it until it begins to burn, then quickly lower it into a bottle of oxygen.

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4. Grasp a piece of magnesium ribbon with the forceps; heat it until it begins to burn, then quickly lower it into a bottle of oxygen.

5. Pour a test tube of water into the last bottle of oxygen and quickly replace the glass plate. Grasp a small piece of steel wool with the forceps; heat it in the flame until it sparkles and then quickly thrust it into the bottle of oxygen. Can you guess why the water was added?

C. OBSERVATIONS.

1. What is the color and odor of oxygen? . . . . . _____

2. Give the name of the method by which we collected oxygen. . . _____

3. Which physical property of oxygen explains why it can be collected in this manner? . . . . _____

4. In what position did you place the bottles of oxygen on the desk (mouth up or down)? . . . _____

5. Does this indicate that oxygen is heavier or lighter than air? . . _____

6. What happened in B-1? . . . _____

7. What happened in B-2? . . . _____

8. Charcoal is chiefly carbon. What compound is formed when carbon burns? . . . . . _____

9. What happened in B-3? . . . _____

10. Suggest a name for the compound formed when sulfur burns. . . _____

11. What happened in B-4? . . . _____

12. Suggest a name for the product formed when magnesium burns. _____

13. What happened in B-5? . . . _____

14. Suggest a name for the product formed when iron burns. . . _____

15. How does the rate of burning compare in air and in oxygen? _____

16. What class of compounds are formed when substances burn? _____

17. What is the scientific name for burning? . . . . . _____

18. Does oxygen support combustion? . . . . . _____

19. Is oxygen combustible? . . . _____

20. What is the test for oxygen? . . _____

DATE..... PERIOD..... NAME.....

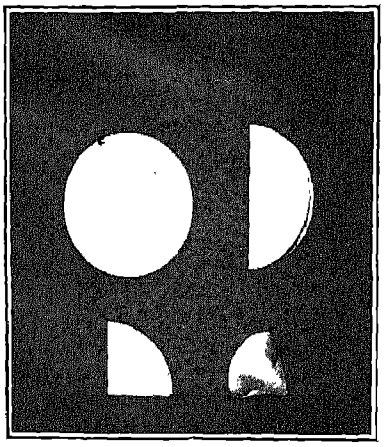
EXPERIMENT 5

FILTRATION AND EVAPORATION

MATERIALS: Generator residue from Experiment 4; potassium chlorate; potassium chloride.

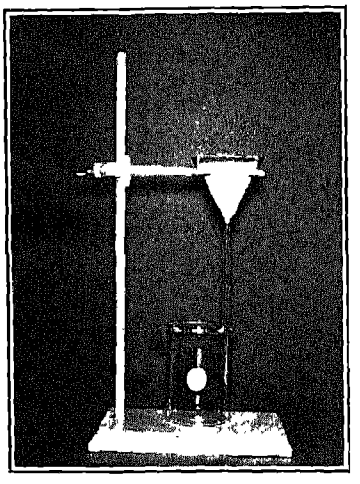
APPARATUS: Ring-stand with ring; funnel; filter paper; beaker; evaporating dish; burner.

Set up the apparatus as shown in the picture. The ring should be placed on the ring-stand in such a way that the end of the funnel, which it supports, will reach about 1/3 of the way down the side of the beaker, which is directly beneath it. The end of the funnel should touch the side of the beaker. This permits the fluid to run down the side of the beaker and prevents spattering.



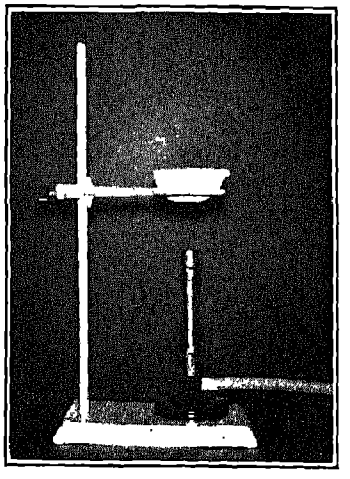
A. FILTRATION.

1. Fold a filter paper at the center so the edges meet evenly. Make a second fold at right angles to the first one.
2. Open the folded filter paper as a cone, so that three layers of paper are on one side and one on the other.
3. Place the cone of filter paper into the funnel and hold it in place. Pour water into the funnel to wet the paper. This makes the filter paper adhere to the sides of the funnel. Pour out the excess water.
4. Fill the generator test tube, from Experiment 4, about 2/3 full of water. Place your finger, or a rubber stopper, over the mouth of the tube and shake it for about a minute.
5. Unstopper the tube, then carefully heat it until the liquid just begins to boil.
6. Filter the muddy liquid by pouring it on the filter paper in the funnel. This method is used for separating solid (undissolved) particles from a liquid.
7. Save the clear liquid (filtrate) which collects in the beaker.
8. Place a small amount of the black residue, which remains on the filter paper, on a watch glass and set it aside to dry.



B. EVAPORATION.

1. Arrange the apparatus as shown in the picture. The ring should be placed about 2 inches above the mouth of the burner.
2. Pour the filtrate (the liquid which has passed through the filter paper) into the evaporating dish.
3. Evaporate the liquid by heating it to boiling, then lower the flame and carefully regulate the heat so as to prevent spattering.
4. Remove the flame before the solid in the dish is completely dry. The heat of the dish is sufficient to complete the process. This method is used for separating a dissolved solid from a liquid.



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C. OBSERVATIONS.

1. What is the appearance of the solid which you obtained in A-6? . . . . . _____
2. Which of the original substances does this solid resemble? . . . . . _____
3. What general name is applied to a solid which has been removed from a liquid in this manner? . . . . . _____
4. Filtration is a process by which -?- (dissolved, undissolved) solids are removed from a liquid. . . . . _____
5. What general name is applied to a liquid which has passed through a filter? . . . _____
6. Evaporation is a process by which -?- (dissolved, undissolved) solids are removed from a liquid. . . . . _____
7. What is the appearance of the dry solid in the evaporating dish? . . . . . _____
8. Taste a crystal of potassium chlorate and a small piece of the solid in the dish. Do they taste the same? . . . . . _____
9. Taste a crystal of potassium chloride and a grain of the solid in the dish. Do they taste the same? . . . . . _____
10. Which reagent was changed during the preparation of oxygen? . . . . . _____
11. What is the function of this substance in this reaction? . . . . . _____
12. Which of the chemicals remained unchanged during the reaction? . . . . _____
13. What part did this substance play in the reaction? . . . . . _____
14. The process in which oxygen combines slowly with other elements, as when iron rusts, is called -?- . . . . . _____
15. The process in which oxygen combines rapidly with other elements, as when wood burns, is called -?-. . . . . _____

Write the word equation for:

16. The burning of carbon: Carbon + _____ → _____
17. The burning of sulfur: _____ + _____ → _____
18. Burning iron wool: _____ + _____ → _____
19. Burning magnesium: _____ + _____ → _____
20. Preparation of oxygen from potassium chlorate: _____ → _____ + _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 6

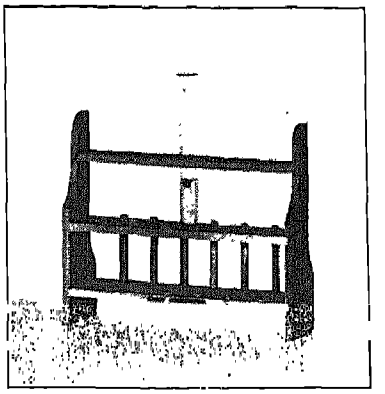
DISPLACEMENT OF HYDROGEN FROM WATER

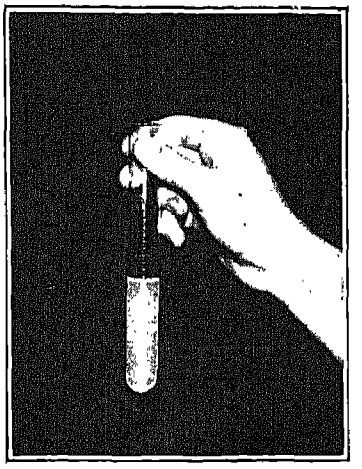
MATERIALS: Sodium; sodium hydroxide solution.

APPARATUS: Test tube; graduated test tube or cylinder; test-tube rack; tweezers; burner; glass rod; litmus paper.

A. EXPERIMENTATION.

1. Fill a test tube ½ full of water and place it in the test tube rack.
2. Get a piece of sodium, about the size of a small pea, from the instructor. Never touch sodium with your fingers—use tweezers.
3. Place the sodium on a piece of filter paper. Fold the paper over the sodium and press out the kerosene. Sodium must be kept in kerosene to prevent it from combining with the moisture and oxygen in the air.
4. Remove the sodium from the paper with tweezers and, holding it at arm's length, drop it into the test tube.
5. Immediately bring a flame to the mouth of the test tube and carefully observe the results.
6. As soon as the action has ceased, feel the sides of the tube at the water level.
7. Dip a clean glass rod into the solution in the test tube and cautiously taste it.
8. Place a drop of the liquid from the test tube on a piece of red and a piece of blue litmus paper. (Acids cause litmus to turn red; bases turn litmus blue.)
9. Rub a drop of the liquid between your fingers. How does it feel? Now wash your fingers thoroughly.
10. Pour 1 ml. (milliliter) of sodium hydroxide into your graduated test tube and then add enough water to make 10 ml. of the solution. In measuring the volume of the liquid in the graduate, always read from the lower part of the curved surface (meniscus) of the liquid. In taking the reading, hold the graduate perpendicular and at such a height that the meniscus comes level with your eye.
11. Taste this solution.
12. Test its effect on litmus paper.
13. Rub a drop of the liquid between your fingers. Identify the feel, then wash your hands.





B. REACTION.

1. Sodium + Water → _____ + _____

Na + HOH → _____ + _____

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C. OBSERVATIONS

1. Why is sodium kept in kerosene? _____
2. What happens when sodium is dropped into water? . . . . _____
3. How does the density of sodium compare with that of water? . . _____
4. What happened when a flame was brought to the mouth of the tube? . . . . . _____
5. Is this action, C-4, evidence of a chemical or a physical change? . _____
6. In this change, C-4, -a- combined with -b- to form -c-. . . . . a. _____ b. _____ c. _____
7. Represent this statement, C-6, by means of a word equation. . . _____ -|- _____ → _____
8. Give the results of A-6. . . . _____
9. This is evidence of a -?- change. _____
10. What is the taste of the liquid in the test tube? . . . . . _____
11. What effect does this liquid have on litmus paper? . . . . . _____
12. What did you prove by the results of A-8? . . . . . _____
13. How did the liquid feel when rubbed between the fingers? . . _____
14. Give the results of A-11. . . . _____
15. What effect did this solution have on litmus paper? . . . . . _____
16. Is sodium hydroxide an acid or a base? . . . . . _____
17. How did it feel? . . . . . _____
18. Summarize the results of C-10, 11, 12, and 13. . . . . _____
19. Summarize the results of C-14, 15, 16, and 17. . . . . _____
20. From a comparison of these results the liquid in the test tube must be a solution of -?-. . . . _____

DATE..... PERIOD..... NAME.....

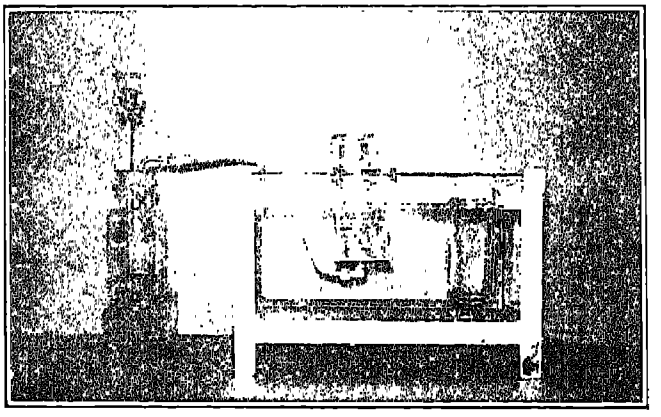
EXPERIMENT 7

HYDROGEN: ITS PREPARATION AND PROPERTIES

MATERIALS: Granulated zinc; sulfuric acid; cupric sulfate solution.

APPARATUS: 5 wide-mouth bottles; 2-hole rubber stopper; 4 glass plates; thistle tube; delivery tube; L-tube; pneumatic trough.

Use one of the bottles as a generator. Wet the glass tubes before inserting them into the stopper with a twisting motion. The end of the thistle tube should come within ¼ of an inch of the bottom of the generator. Fill the 4 remaining bottles with water and invert them in the trough where they will be ready for use. Be sure there are no air bubbles in the bottle. All parts of the apparatus should fit snugly. A mixture of hydrogen and air is very explosive, therefore keep all flames away from the generator.



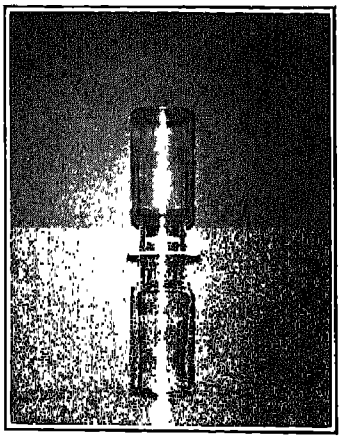
A. PREPARATION.

1. Put about 10 grams, a level teaspoon, of zinc into the generator.
2. Replace the stopper firmly and see that all connections are air-tight.
3. Pour about 20 ml. of water through the thistle tube. This should bring the end of the thistle tube below the surface of the water.
4. Add a few drops of cupric sulfate solution. This serves the same purpose in the preparation of hydrogen that manganese dioxide does in the preparation of oxygen.
5. When ready to collect the gas, add a few drops of concentrated sulfuric acid. The speed of the reaction can easily be regulated by the quantity of acid which is added from time to time.
6. Collect 4 bottles of hydrogen by the displacement of water.
7. Place glass plates over the mouth of the bottles, while still under water, then remove the bottles and place them mouth-downward on the desk.



B. EXPERIMENTATION.

1. Bring a burning splint to the mouth of the first bottle of gas as you lift it straight up from the desk.
2. Lift one of the other bottles of hydrogen straight up and insert a burning splint into it. Continue the operation even though a muffled report is heard. Now slowly remove the splint. Do this several times.
3. Place a bottle of hydrogen mouth-upward on the desk and remove the plate. After about a minute, bring a burning splint to its mouth.
4. Place a bottle of hydrogen over a bottle of air and remove the cover plate. Let the two bottles remain in this position for about three minutes. Now bring a burning splint to the mouth of each bottle.



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C. OBSERVATIONS.

1. Why must the end of the thistle tube extend below the surface of the liquid in the generator? . . . . . _____

2. Which property of hydrogen explains why we can collect it by the displacement of water? _____

3. After the hydrogen had been collected, the bottles were placed mouth -?- on the desk. _____

4. Which property of hydrogen is responsible for this procedure? . . . . . _____

5. What gas filled the generator before the chemicals began to react? . . . . . _____

6. What happened when a burning splint was brought to the mouth of the first bottle of gas collected? . . . . . _____

7. What does this tell us about the composition of the first bottle of gas? . . . . . _____

8. What happened when a burning splint was brought to the mouth of one of the other bottles? . . . . . _____

9. What does this tell us about the composition of this bottle of gas? . . . . . _____

10. What happens to a burning splint when it is thrust up into a bottle of pure hydrogen? . . _____

11. What happens when the splint is slowly withdrawn? . . . . . _____

12. Why did this take place? . . . . . _____

13. What collected on the inside of the bottle? . _____

14. What compound is formed when hydrogen burns? . . . . . _____

15. What happens when a burning splint is brought to the mouth of a bottle of hydrogen which has remained uncovered for a minute? _____

16. What does this prove about the relative densities of air and hydrogen? . . . . . _____

17. What happened when a burning splint was brought to the mouth of each of the bottles in B-4? . . . . . _____

18. What must have taken place when the glass plate was removed from between these two bottles? . . . . . _____

19. From which of the chemicals used in this experiment was hydrogen obtained? . . . . _____

20. What was the function of cupric sulfate in this reaction? . . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 8

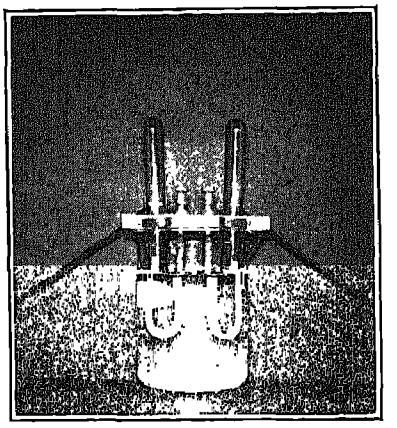
ELECTROLYSIS OF WATER

MATERIALS: Distilled water; concentrated (conc.) sulfuric acid.

APPARATUS: Electrolysis apparatus; 2 graduated test tubes; source of direct current electricity (storage battery, 3 or 4 dry cells connected in series, or a direct current circuit); splints.

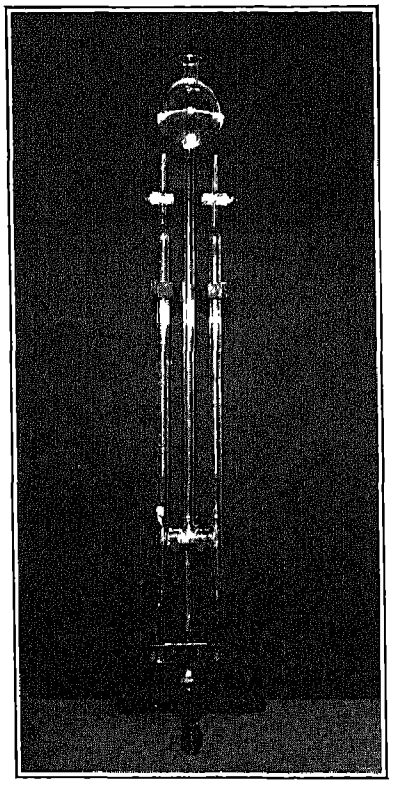
Any type of electrolysis apparatus may be used. The two types shown are very satisfactory. Be very careful that the two wires from the source of the direct current electricity do not touch each other and thus produce a short-circuit.

A. ELECTROLYSIS.



1. Measure about 100 ml. of distilled water into a beaker and use this to fill the electrolysis apparatus.
2. Connect the electrodes of the apparatus to the source of direct current.
3. Observe whether electrolysis (decomposition by electricity) takes place. If bubbles are being formed at the electrodes the water is being decomposed.
4. Turn off the electricity and pour the distilled water from the apparatus back into the beaker.
5. Measure 5 ml. of concentrated sulfuric acid and pour it into a clean beaker containing 100 ml. of distilled water.
6. Fill the electrolysis apparatus with this mixture and turn on the electricity.
7. Observe whether electrolysis takes place this time. (The sulfuric acid serves only to conduct electricity through the water.)

B. EXPERIMENTATION.



1. If using the upper apparatus, skip to B-4, otherwise connect one end of a delivery tube to each arm of the electrolysis apparatus and let the opposite end of each tube extend to the bottom of a beaker which is about ¾ full of water.
2. Turn on the current and let the gases pass through the delivery tubes for 2 or 3 minutes.
3. Turn off the current. Fill two graduated test tubes with water. Place your thumb or a piece of paper over the mouth of each tube and place them mouth-downward over the delivery tube in each of the beakers.
4. Let electrolysis continue until one of the tubes contains 20 ml. of gas. Turn off the current momentarily and compare the volumes of the gases in the two tubes.
5. Continue the electrolysis until one of the tubes is full of gas. Cover the mouth of the tube as you remove it from the beaker and immediately test the gas with a burning splint.
6. Remove the other tube in the same manner, even though it is not full of gas, and test it with a burning splint.

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C. OBSERVATIONS.

1. What happened in A-3? . . . _____

2. Will distilled water conduct electricity? . . . . . _____

3. What happened in A-7? . . . _____

4. What is the function of sulfuric acid in the electrolysis of water? _____

5. What is the function of electricity in this experiment? . . . . _____

6. What is the reason for B-2? . . _____

7. Which physical property of these gases explains why they can be collected by this method? . . . _____

8. Give the name of the method by which these gases were produced. _____

9. Give the name of the method by which these gases were collected. _____

10. Give the results of B-4. . . . _____

11. What happened in B-5? . . . _____

12. What is the name of this gas? . _____

13. What happened in B-6? . . . _____

14. What is the name of this gas? . _____

15. What do these results show about the composition of water by volume? . . . . . _____

16. What does the formula for water (H_2O) tell you about its composition by volume? . . . . . _____

17. What is electrolysis? . . . . _____

18. Write the word equation for the electrolysis of water . . . . _____ → _____ + _____

19. Complete this word equation: Sodium + Water → _____ + _____

20. Complete this word equation: Iron + Water → _____ + _____

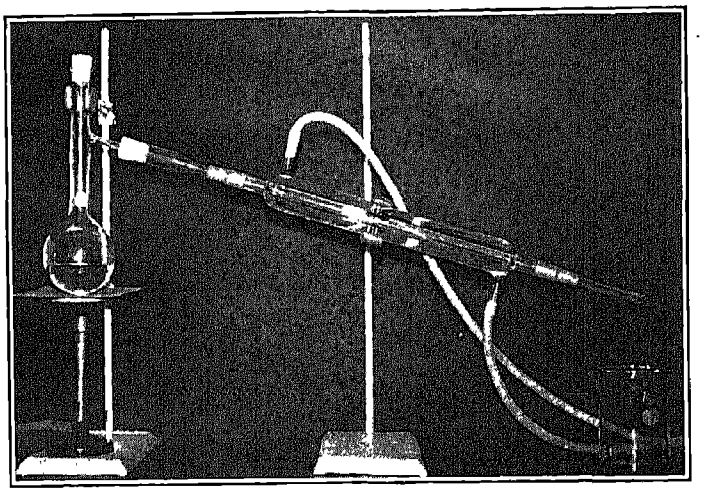
DATE..... PERIOD..... NAME.....

EXPERIMENT 9

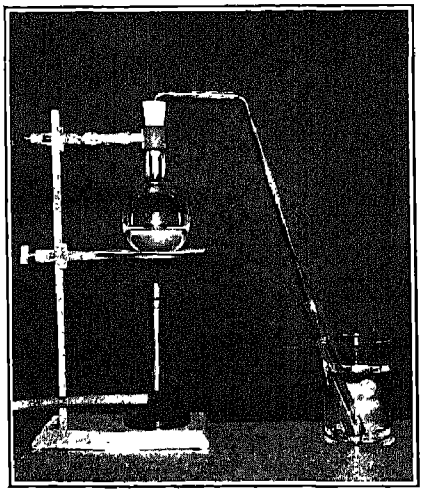
DISTILLATION OF WATER

MATERIALS: Ammonium hydroxide; potassium permanganate; sodium chloride; phenolphthalein, 1% solution.

APPARATUS: Distilling flask or Florence flask; Liebig condenser or bent glass condensing tube; 2 beakers, 400 ml.; 6 test tubes; 2 watch glasses; test-tube rack.

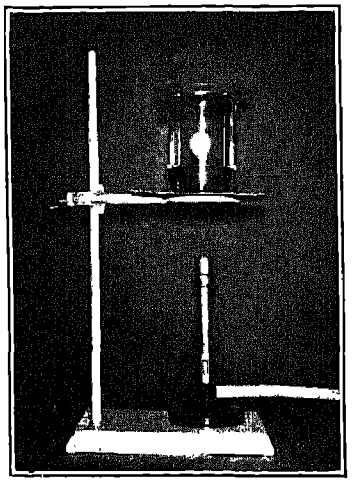


When a liquid changes to a vapor (evaporates) it leaves behind all solid matter which may have been dissolved in it. This method of separation is possible because liquids usually vaporize (change into a vapor) more readily than solids. The method of removing dissolved solids from a liquid by heating the solution until the liquid evaporates and then condensing its vapors is called distillation.



A. DISTILLATION.

1. Assemble the distilling apparatus as shown in one of the pictures. If a Liebig condenser is used, water from the faucet should flow in at the lower opening and out at the upper opening.
2. Fill the distilling flask about ½ full of tap water.
3. Add 2 or 3 crystals of potassium permanganate.
4. Add ½ of a level teaspoon of sodium chloride, a solid.
5. By means of your glass rod, add 1 drop of ammonium hydroxide (ammonia gas dissolved in water).
6. Heat the flask to gentle boiling and collect the liquid which distills over (the distillate) in test tubes.
7. Collect 6 test tubes, each ½ full, of the distillate. Discard the first because it contains impurities from the condenser. Arrange the remaining five test tubes in the test-tube rack in the order in which they were collected.



B. EXPERIMENTATION.

1. Use a clean, dry stirring rod to place 2 or 3 drops of the distillate from the first test tube on a clean, dry watch glass.
2. Evaporate this liquid to dryness over a steam bath. (Place the watch glass over the top of the beaker which is ¼ full of water. Heat until the boiling water in the beaker causes the distillate on the watch glass to evaporate to dryness.)
3. Place 2 or 3 drops of tap water on another clean, dry watch glass and repeat B-1 & 2. Compare the amounts of residue (solid matter left on the watch glass) resulting from the evaporation of equal volumes of distillate and tap water.

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4. Add a drop of phenolphthalein solution to each of the 5 test tubes of distillate. The presence of ammonia (a base) causes phenolphthalein to turn red. Which of the test tubes *contains* the greatest amount of ammonia?

5. Fill a beaker with water to within 1/4 inch of the top. Add 1 drop of ammonium hydroxide and 1 drop of phenolphthalein. Boil slowly and observe the results.

C. OBSERVATIONS.

1. What is evaporation? . . . . _____

2. What is condensation? . . . . _____

3. What is distillation? . . . . _____

4. What is the distillate? . . . _____

5. What is the residue? . . . . _____

6. Why should water flow in at the bottom of a Liebig condenser and out at the top? . . . . . _____

7. Why is the condenser tube surrounded by running water? . . _____

8. Why was the first tube of distillate discarded? . . . . . _____

9. Why do some liquids leave a residue when they evaporate? . . _____

10. Is a residue left when tap water evaporates? . . . . . _____

11. Is a residue left when distilled water evaporates? . . . . . _____

12. What happens when phenolphthalein is added to a test tube containing tap water? . . . _____

13. What happens when phenolphthalein is added to water containing ammonium hydroxide? . _____

14. What happened in B-4? . . . _____

15. What did this difference in color indicate? . . . . . _____

16. Can a liquid be separated from dissolved gases by distillation? . _____

17. What happened in B-5? . . . _____

18. What does this indicate? . . . _____

19. How may dissolved gases be separated from a liquid? . . . . _____

20. What class of impurities are removed by distillation? . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 10

WATER OF CRYSTALLIZATION

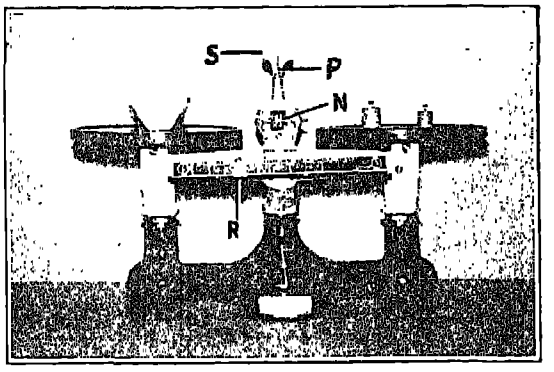
MATERIALS: Cupric sulfate (blue vitriol).

APPARATUS: Platform balance; set of weights; crucible; ring-stand, with ring; clay triangle; burner.

Many compounds combine with water (water of crystallization) to form crystalline compounds called hydrates. The water of crystallization which combines with the compound to form the hydrate is usually held rather loosely and can be driven off by heat. A compound from which the water of crystallization has been removed is said to be anhydrous. Water of crystallization is sometimes called "water of hydration."

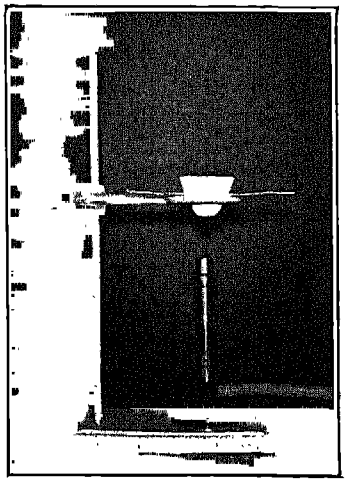
$BaCl_2 \cdot 2H_2O$ is an example of the way the formula for a hydrate is written. The period between the $BaCl_2$ and the $2H_2O$ indicates that the water is combined chemically with the barium chloride. It indicates the *addition* of water to the compound, not multiplication as in mathematics.

A. WEIGHING.



1. Be sure the platforms are both clean and the rider (R) is at the extreme left end of the scale.
2. Touch one platform lightly to set the pointer (P) swinging. If the pointer does not move an equal distance on each side of the center line on the scale (S), turn the adjustment nut (N) until it does.
3. Place the object to be weighed on the left platform.
4. Place a weight on the right platform which you think will just about equal the weight of the object on the left platform. If it is too heavy, remove it and use the next smaller weight. If it is too light, remove it and use the next larger weight. Use as small a number of weights as possible and DO NOT USE weights which weigh less than 10 grams.
5. Continue by moving the rider (R) over the graduated scale until the pointer swings an equal number of divisions on either side of the center line.
6. The weight of the object equals the sum of the weights on the platform + the weight shown on the scale, by the rider. The numbers on the *graduated scale indicate grams, and the small divisions* are tenths of a gram (written 0.1, 0.2, etc.).

B. EXPERIMENTATION.



1. Weigh the porcelain crucible as accurately as possible and record its weight in C-2.
2. Put about a level teaspoon, 3 to 4 grams, of cupric sulfate into the crucible and weigh it again. Record this weight in C-1 and in C-4.
3. Assemble the apparatus as shown in the picture.
4. Heat the crucible very gently for 3 or 4 minutes to prevent the cupric sulfate from spattering, and observe the changes which take place in the compound. If you lose any of the compound by spattering, your results will be inaccurate.

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5. Continue the heating for about 10 minutes longer at a slightly higher temperature. Do not stir the compound, or you will lose some of it when you remove the stirring rod.

6. Remove the flame and let the crucible remain on the triangle until it is cool.

7. Weigh the crucible and record its weight.

8. Place the crucible back on the triangle and continue the heating at 5 minute intervals until the last two consecutive weights are the same. Record this weight in C-5.

9. Calculate the percentage of water of crystallization.

C. RESULTS.

1. Weight of crucible and crystalline cupric sulfate . . . . gms.

2. Weight of crucible . . . . gms.

3. Weight of hydrated cupric sulfate. (Subtract C-2 from C-1) . . . . gms.

4. Weight of crucible and crystalline cupric sulfate . . . . gms.

5. Constant weight of crucible and anhydrous cupric sulfate . . . . gms.

6. Weight of water of crystallization. (Subtract C-5 from C-4) . . .. gms.

7. Water of crystallization $= \frac{\text{Wt. of water x 100}}{\text{Wt. of hydrate}} =$ . . . . %

D. OBSERVATIONS.

1. Why must the platform of the balance be cleaned before starting to weigh? . . . . . _____

2. The object to be weighed must be placed on the -?- platform of the balance. . . . . _____

3. Why was the hydrate heated very gently at first? . . . . . _____

4. What happened in B-4? . . . _____

5. Why was the crucible allowed to cool before it was placed on the balance? . . . . . _____

6. Why was the weight of the compound different before and after heating? . . . . . _____

7. Why was the crucible re-heated and re-weighed several times? _____

8. What is the percentage of water of crystallization in crystalline cupric sulfate? . . . . . _____

9. How does your answer compare with others in the class? . . _____

10. Which chemical law does this illustrate? . . . . . _____

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EXPERIMENT 11

SOLUTIONS

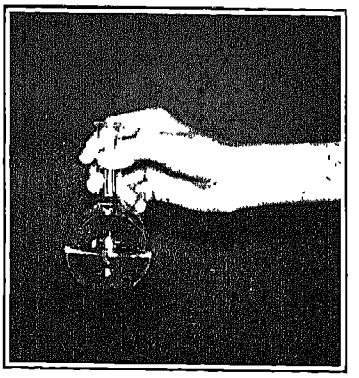
MATERIALS: Sodium chloride, 25 grams (large crystals).

APPARATUS: Flask, 250 ml.; beaker, 250 ml.; ring-stand and ring; wire gauze; burner.

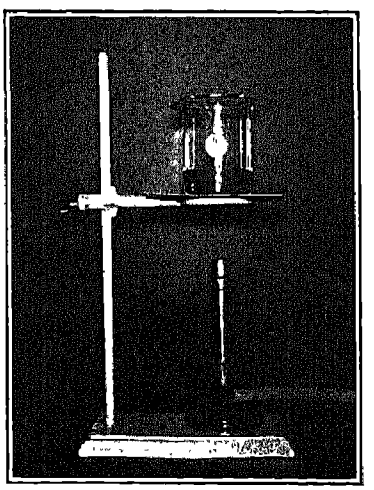
Solutions are mixtures which are composed of two parts—the solute and the solvent. The solute is the part which dissolves or distributes itself uniformly through a solvent. Usually the solvent is the part of the solution which is most abundant. Air is an example of a solution of gases; tin and lead form a solid solution called an alloy; alcohol and water form a solution of liquids. If the solution contains a greater percentage of alcohol than water, then alcohol is called the solvent, and water is the solute. But, if the solution contains a greater percentage of water than alcohol, then water is the solvent and alcohol is the solute. Solute + Solvent = Solution.

Solutions may be unsaturated, saturated, supersaturated, concentrated or dilute. If more of the solute will dissolve in the solvent, at the same temperature or pressure, the solution is said to be unsaturated. A saturated solution is one which contains all of the solute that will dissolve in it without changing the temperature or pressure. A supersaturated solution is one in which the solvent contains more of the solute than would dissolve in it at the present conditions. A concentrated solution is one which contains a large amount of solute in the solvent, and a dilute solution contains a small amount of solute dissolved in the solvent.

A. EXPERIMENTATION.



1. Measure 50 ml. of water into a 250 ml. flask.
2. Weigh out 25 grams of sodium chloride (salt, large crystals). Place a piece of filter paper on each platform of the balance. Put a 20 gram weight on the right platform and move the rider to 5 grams. Pour the salt on the filter paper on the left platform until the two platforms just balance.
3. Pour about half of the salt into the flask. Shake the flask with a rotary motion until all of the salt has dissolved.
4. Continue adding small quantities of salt and shaking the flask until no more salt will dissolve.
5. Pour the salt solution into a clean, dry beaker, being careful that the undissolved salt remains in the flask.
6. Put 2 or 3 crystals of salt into the beaker and stir the solution with the stirring rod. Observe whether the crystals dissolve.
7. Weigh the salt which you have left and from this calculate the solubility of sodium chloride.
8. Take the temperature of the solution and record the temperature at which the solubility was determined.
9. Place the beaker on a wire gauze on the ring-stand and heat until the solution just begins to boil.
10. Remove the flame and add small quantities of salt, stirring constantly, until no more will dissolve.
11. Again heat and stir the solution until all of the salt in the bottom of the beaker has dissolved.
12. Now remove the flame and observe what happens as the solution cools.



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B. OBSERVATIONS.

1. What is used as the solvent in this experiment? . . . . . _____
2. What is the solute? . . . . . _____
3. What kind of solution* is formed in A-3? . . . . . _____
4. What kind of solution is formed in A-4? . . . . . _____
5. What happened to the crystals of salt in A-6? . . . . . _____
6. What did this indicate about the kind of solution? . . . . . _____
7. What was the temperature of the solution? . . . . . _____
8. How much salt dissolved in 50 ml. of water at this temperature? _____
9. What is the solubility of salt at this temperature? . . . . . _____
10. Why is it necessary to tell the temperature at which the solubility is determined? . . . . . _____
11. What kind of solution was formed in A-9? . . . . . _____
12. Why do you think that your classification of the solution in A-9 is correct? . . . . . _____
13. What kind of solution is formed in A-11? . . . . . _____
14. What happened as the solution cooled? . . . . . _____
15. Explain why this happened. . . _____
16. Is the preparation of a solution a physical or a chemical change? _____
17. What do we mean when we say that solutions are homogeneous? _____
18. What effect does temperature have on the solubility of a solid in a liquid? . . . . . _____
19. How does temperature affect the speed at which a solid dissolves in a liquid? . . . . . _____
20. What would you do to recover the salt from the solution? . . _____

* Unsaturated, saturated, or supersaturated.

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EXPERIMENT 12

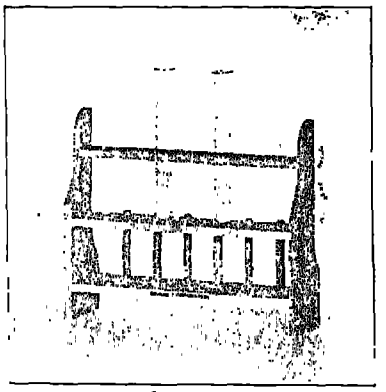
CONDITIONS AFFECTING SOLUTION FORMATION

MATERIALS: Calcium carbonate (limestone); potassium aluminum sulfate (potassium alum); sodium bicarbonate; sodium chloride, small crystals (table salt) and large crystals (ice cream salt); hydrochloric acid; kerosene.

APPARATUS: 2 test tubes; test-tube rack; 2 solid rubber stoppers, No. 2.

A. NATURE OF THE SOLUTE.

1. Fill 2 test tubes ½ full of water and place them in the rack.
2. Drop a small lump of potassium alum into one of the tubes and a small lump of limestone into the other.
3. Place stoppers into the tubes and, holding both tubes in the same hand, shake them for about 5 minutes.
4. Return the tubes to the rack and observe which of the solutes has dissolved.



B. NATURE OF THE SOLVENT.

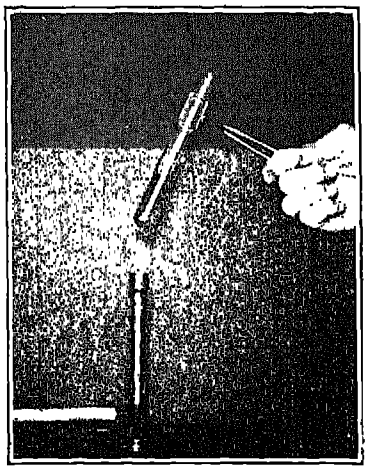
1. Pour a level teaspoon of salt into each of 2 test tubes.
2. Fill one of the tubes ½ full of water, and the other ½ full of kerosene.
3. Stopper both tubes and shake them for 2 minutes.
4. Return the tubes to the rack and observe the results.

C. AGITATION (Stirring or Shaking).

1. Fill 2 test tubes ½ full of water and place them in the rack.
2. Pour a level teaspoon of salt in each tube.
3. Stopper one of the tubes and shake it just long enough for the salt to dissolve.
4. Return the tube to the rack and compare the results.

D. DEGREE OF PULVERIZATION (Size of the particles).

1. Fill 2 test tubes ½ full of water and place them in the rack.
2. Pour a level teaspoon of table salt into one of the tubes and an equal amount of ice cream salt into the other.
3. Stopper both tubes and shake them just long enough for the salt to dissolve in one of the tubes.
4. Return them to the rack and compare results.



E. TEMPERATURE.

1. Solids in Liquids.
   a. Pour a level teaspoon of salt into each of 2 test tubes.
   b. Fill one of the tubes ½ full of hot water and pour an equal volume of cold water into the other tube.
   c. Stopper both tubes and shake them just long enough for the salt to dissolve in one of them.
2. Gases in Liquids.
   a. Fill a test tube ¾ full of cold water.
   b. Hold the tube in a slightly inclined position over a small flame.
   c. Observe what happens as the water is slowly warmed.

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F. PRESSURE.

1. Gases in Liquids.
   a. Dissolve a half teaspoon of sodium bicarbonate in ¾ of a test tube of cold water.
   b. Add 5 drops of HCl to the tube and observe the results. Use a medicine dropper.
   c. Add 5 drops more of hydrochloric acid, quickly stopper the tube, and hold the stopper tightly in place.
   d. While still holding the stopper firmly in place, shake the tube a few times.
   e. After the bubbles have disappeared from the liquid, remove the stopper and observe the results.

G. OBSERVATIONS.

1. What is a solute? . . . . . _____
2. Give the names of the solutes used in "A." . . . . . _____
3. Which of these solutes is insoluble in water? . . . . . _____
4. What is a solvent? . . . . . _____
5. Give the names of the solvents used in "B." . . . . . _____
6. In which of the solvents is salt insoluble? . . . . . _____
7. Give the results of "C." . . . _____
8. State one way of increasing the rate at which a solid dissolves in a liquid (G-7). . . . . _____
9. Give the results of "D." . . . _____
10. State a second way of increasing the rate at which a solid dissolves in a liquid (G-9). . . . . _____
11. Give the results of E-1. . . . _____
12. State a third way of increasing the rate at which a solid dissolves in a liquid (G-11) . . . . . _____
13. Give the results of E-2. . . . _____
14. What effect does an increase in temperature have on the solubility of gases in liquids? . . . . . _____
15. What effect does an increase in temperature have on the solubility of solids in liquids? . . . . _____
16. Give the results of F-1 b. . . . _____
17. Give the results of F-1 e. . . . _____
18. Why did this happen? . . . _____
19. What is effervescence? . . . _____
20. What effect does an increase in pressure have on the solubility of gases in liquids? . . . . . _____

FORMULAS · 1

	Iodide	Oxide	Hydroxide	Sulfate	Chlorate	Bicarbonate	Acetate
Hydrogen							
Barium							
Ferric							
Calcium							
Sodium							
Magnesium							
Stannic							
Lead							
Mercurous							
Chromium							
Cobalt							
Ammonium							
Cadmium							
Potassium							
Manganese							
Aluminum							
Zinc							
Antimony							
Stannous							
Silver							
Cupric							
Arsenous							
Strontium							
Bismuth							
Mercuric							
Arsenic							
Nickel							
Cuprous							
Ferrous							

FORMULAS - 2

	Chloride	Sulfide	Carbonate	Nitrate	Bisulfite	Chromate	Permanganate
Hydrogen							
Barium							
Ferric							
Calcium							
Sodium							
Stannic							
Lead							
Mercurous							
Chromium							
Magnesium							
Ammonium							
Cobalt							
Potassium							
Manganese							
Aluminum							
Cadmium							
Antimony							
Stannous							
Silver							
Cupric							
Arsenous							
Strontium							
Bismuth							
Mercuric							
Arsenic							
Nickel							
Cuprous							
Ferrous							
Zinc							

FORMULAS - 3

	Fluoride	Nitride	Phosphate	Nitrite	Bisulfate	Manganate	Dichromate
Hydrogen							
Barium							
Ferric							
Calcium							
Sodium							
Magnesium							
Stannic							
Lead							
Mercurous							
Chromium							
Cobalt							
Ammonium							
Cadmium							
Potassium							
Manganese							
Aluminum							
Zinc							
Antimony							
Stannous							
Silver							
Cupric							
Arsenous							
Strontium							
Bismuth							
Mercuric							
Arsenic							
Nickel							
Cuprous							
Ferrous							

FORMULAS - 4

	Bromide	Cyanide	Sulfite	Oxalate	Silicate	Arsenate	Bicarbonate
Hydrogen							
Barium							
Ferric							
Calcium							
Sodium							
Magnesium							
Stannic							
Lead							
Mercurous							
Chromium							
Cobalt							
Ammonium							
Cadmium							
Potassium							
Manganese							
Aluminum							
Zinc							
Antimony							
Stannous							
Silver							
Cupric							
Arsenous							
Strontium							
Bismuth							
Mercuric							
Arsenic							
Nickel							
Cuprous							
Ferrous							

DATE..... PERIOD..... NAME.....

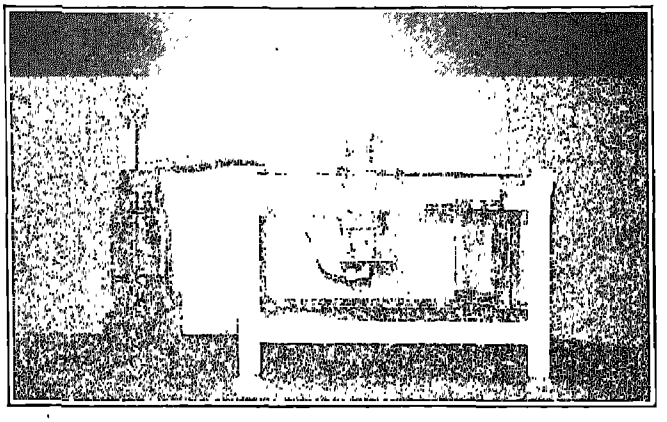
EXPERIMENT 13

CARBON DIOXIDE: ITS PREPARATION AND PROPERTIES

MATERIALS: Marble chips, $CaCO_3$; hydrochloric acid; limewater, $Ca(OH)_2$; magnesium ribbon; wood splints; candle.

APPARATUS: Pneumatic trough; thistle tube; 5 wide-mouth bottles; 2 test tubes; litmus paper; rubber stoppers.

Assemble the apparatus as shown in the picture, using one of the wide-mouth bottles for the generator. Be sure to wet both the thistle tube and the stopper before attempting to put them together. The end of the thistle tube should extend down to within 1/8 of an inch of the bottom of the generator.



A. PREPARATION

1. Remove the stopper and pour a rounded teaspoon of marble chips into the generator.
2. Replace the stopper and add enough water, about 15 ml., to cover the end of the thistle tube.
3. Fill 4 wide-mouth bottles with water and place them in the pneumatic trough, ready for collecting the gas.
4. Add small quantities of hydrochloric acid from time to time to regulate the flow of gas.
5. Collect 4 bottles of carbon dioxide by the displacement of water. Cover the mouths of the bottles with glass plates and place them upright on the desk.

B. EXPERIMENTATION.

1. Remove the delivery tube from the trough and observe the color and odor of carbon dioxide.
2. Pour 10 ml. of limewater into a test tube. Now pass carbon dioxide from the delivery tube into the limewater. Observe the results. This is the test for carbon dioxide.
3. Collect a test tube of carbon dioxide by the upward displacement of air. Pour 5 ml. of water into the test tube of carbon dioxide. Close the mouth of the tube with a one-hole rubber stopper, place your finger over the hole, then shake the tube for about a minute. Now place the mouth of the tube under water, and remove your finger from over the hole. Observe the results.
4. Disconnect the apparatus. Rinse the marble chips with water and place them into the beaker on the front desk.
5. Insert a burning splint into a bottle of the gas and observe whether carbon dioxide supports combustion.
6. Place a candle upright in a beaker and light it. Pour carbon dioxide from one of the bottles into the beaker, as if it were water.
7. Wet a piece of red and a piece of blue litmus paper and lower them into a bottle of carbon dioxide. Acids turn litmus paper red; bases turn litmus blue.
8. Grasp a piece of magnesium ribbon, about 3 cm. long, with the tweezers and ignite it in a flame. Let it burn in the air and observe the product formed.
9. Ignite another piece of magnesium ribbon and quickly thrust it into a bottle of carbon dioxide. Observe the results.
10. Burn a splint in a wide-mouth bottle. Remove the ash, and add 10 ml. of limewater. Place a rubber stopper in the mouth of the bottle and shake it. Observe the results.
11. Gently blow through a glass tube into a test tube containing 10 ml. of limewater. Observe the results.

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C. OBSERVATIONS.

1. Why should the thistle tube extend nearly to the bottom of the bottle? . . . . . _____

2. What two chemicals were used in the preparation of CO_2? . . . _____

3. Write a double replacement equation for the reaction. . . . _____ + _____ → _____ + _____

4. Write an equation for the decomposition of carbonic acid. . . . _____ → _____ + _____

5. What is the color and odor of carbon dioxide? . . . . . _____

6. What happened in B-2? . . _____

7. Complete and balance: . . . CO_2 + $Ca(OH)_2$ → _____ + _____

8. Give the common name and the chemical name for the white precipitate formed in B-2. . . . _____

9. What happened in B-3? . . . _____

10. This shows that carbon dioxide is -?- (a physical property). . _____

11. What happened in B-5? . . . _____

12. This shows that carbon dioxide -?- (a chemical property). . . _____

13. What happened in B-6? . . . _____

14. This shows that carbon dioxide is -?- (a physical property). . _____

15. What happened in B-7? . . . _____

16. Show by an equation how carbon dioxide combines with water. . _____ + _____ → _____

17. What is the appearance of the product formed in B-8? . . . _____

18. Write an equation for the reaction which occurred in B-8. . . . _____ + _____ → _____

19. What is the appearance of the product formed in B-9? . . _____

20. Write an equation for the reduction of carbon dioxide by magnesium. . . . . _____ + _____ → _____ + _____

EQUATIONS — 1

1. Decomposition of mercuric acid: _____ + _____ → _____ + _____
2. Decomposition of potassium chlorate: _____ + _____ → _____ + _____
3. Decomposition of carbonic acid: _____ + _____ → _____ + _____
4. Electrolysis of water: _____ + _____ → _____ + _____
5. Electrolysis of salt: _____ + _____ → _____ + _____
6. Combination of sodium and chlorine: _____ + _____ → _____ + _____
7. Combination of copper and chlorine: _____ + _____ → _____ + _____
8. Combination of antimony and chlorine: _____ + _____ → _____ + _____
9. Complete combustion of carbon: _____ + _____ → _____ + _____
10. Incomplete combustion of carbon: _____ + _____ → _____ + _____
11. Combustion of carbon monoxide: _____ + _____ → _____ + _____
12. Carbon dioxide + water: _____ + _____ → _____ + _____
13. Sodium + water: _____ + _____ → _____ + _____
14. Zinc + sulfuric acid: _____ + _____ → _____ + _____
15. Zinc + hydrochloric acid: _____ + _____ → _____ + _____
16. Sodium + hydrochloric acid: _____ + _____ → _____ + _____
17. Aluminum + hydrochloric acid: _____ + _____ → _____ + _____
18. Carbon dioxide + limewater: _____ + _____ → _____ + _____
19. Calcium carbonate + hydrochloric acid: _____ + _____ → _____ + _____
20. Sodium bicarbonate + sulfuric acid: _____ + _____ → _____ + _____
21. Sodium hydroxide + hydrochloric acid: _____ + _____ → _____ + _____
22. Silver nitrate + sodium chloride: _____ + _____ → _____ + _____
23. Sulfuric acid + sodium chloride: _____ + _____ → _____ + _____
24. Barium chloride + sodium sulfate: _____ + _____ → _____ + _____
25. Ammonium hydroxide + hydrochloric acid: _____ + _____ → _____ + _____

26. Sulfuric acid + sodium nitrate: _____ + _____ → _____ + _____

27. Ferric chloride + sodium hydroxide: _____ + _____ → _____ + _____

28. Manganese dioxide + hydrochloric acid: _____ + _____ → _____ + _____

29. Sodium oxide + hydrochloric acid: _____ + _____ → _____ + _____

30. Calcium hydroxide + sulfuric acid: _____ + _____ → _____ + _____

31. Zinc hydroxide + sodium: _____ + _____ → _____ + _____

32. Cupric oxide + nitric acid: _____ + _____ → _____ + _____

33. Sodium acetate + ferrous iodide: _____ + _____ → _____ + _____

34. Potassium silicate + strontium chlorate: _____ + _____ → _____ + _____

35. Antimony hydroxide + hydrochloric acid: _____ + _____ → _____ + _____

36. Aluminum hydroxide + hydrogen sulfate: _____ + _____ → _____ + _____

37. Ammonium hydroxide + lead nitrate: _____ + _____ → _____ + _____

38. Aluminum + ferric oxide: _____ + _____ → _____ + _____

39. Barium hydroxide + nitric acid: _____ + _____ → _____ + _____

40. Ammonium hydroxide + calcium chloride: _____ + _____ → _____ + _____

41. Aluminum sulfate + hydrogen hydroxide: _____ + _____ → _____ + _____

42. Iron + cupric sulfate: _____ + _____ → _____ + _____

43. Sodium nitrate + potassium chloride: _____ + _____ → _____ + _____

44. Calcium sulfate + sodium carbonate: _____ + _____ → _____ + _____

45. Arsenic chloride + hydrogen sulfide: _____ + _____ → _____ + _____

46. Copper + silver sulfide: _____ + _____ → _____ + _____

47. Sodium + acetic acid: _____ + _____ → _____ + _____

48. Sodium bicarbonate + sulfuric acid: _____ + _____ → _____ + _____

49. Ammonium hydroxide + hydrobromic acid: _____ + _____ → _____ + _____

50. Sodium carbonate + hydrogen sulfate: _____ + _____ → _____ + _____

51. Potassium hydroxide + phosphoric acid: _____ + → + _____

52. Arsenous chloride + hydrogen sulfide: _____ + → + _____

53. Zinc acetate + silver nitrate: _____ + → + _____

54. Magnesium nitrate + ferrous chlorate: _____ + → + _____

55. Sodium sulfide + aluminum bromide: _____ + → + _____

56. Cupric sulfate + calcium nitrate: _____ + → + _____

57. Potassium bromide + mercurous acetate: _____ + → + _____

58. Aluminum chlorate + sodium sulfate: _____ + → + _____

59. Cupric nitrate + calcium iodide: _____ + → + _____

60. Ammonium sulfate + potassium carbonate: _____ + → + _____

61. Potassium + chlorine: _____ + → + _____

62. Sodium chlorate + heat: _____ + → + _____

63. Zinc carbonate + heat: _____ + → + _____

64. Magnesium oxide + water (combination): _____ + → + _____

65. Calcium oxide + carbon dioxide (combin.): _____ + → + _____

66. Zinc oxide + carbon (reduction): _____ + → + _____

67. Ferric oxide + carbon monoxide (reduction): _____ + → + _____

68. Arsenic oxide + water (arsenic acid anhydride): _____ + → + _____

69. Nitric acid anhydride (N_2O_5) + water: _____ + → + _____

70. Zinc + lead nitrate: _____ + → + _____

71. Lead sulfide + oxygen: _____ + → + _____

72. Ammonium sulfate + potassium carbonate: _____ + → + _____

73. Sodium silicate + aluminum chloride: _____ + → + _____

74. Ferric chlorate + cupric chromate: _____ + → + _____

75. Potassium chlorate + sodium phosphate: _____ + → + _____

76. Aluminum oxide + magnesium sulfate; _____ + _____ → _____ + _____

77. Lead acetate + ammonium phosphate: _____ + _____ → _____ + _____

78. Zinc nitrate + potassium chloride: _____ + _____ → _____ + _____

79. Calcium chloride + ferrous acetate: _____ + _____ → _____ + _____

80. Sodium oxide + cupric chloride: _____ + _____ → _____ + _____

81. Lead chlorate + ammonium nitrate; _____ + _____ → _____ + _____

82. Magnesium chromate + aluminum nitrate: _____ + _____ → _____ + _____

83. Silver acetate + manganese chromate: _____ + _____ → _____ + _____

84. Potassium chromate + calcium chloride: _____ + _____ → _____ + _____

85. Ferrous bromide + sodium nitrate: _____ + _____ → _____ + _____

86. Silver chloride + zinc iodide: _____ + _____ → _____ + _____

87. Aluminum sulfate + potassium hydroxide: _____ + _____ → _____ + _____

88. Calcium acetate + sodium oxide: _____ + _____ → _____ + _____

89. Ammonium iodide + stannous acetate: _____ + _____ → _____ + _____

90. Potassium iodide + mercurous chloride: _____ + _____ → _____ + _____

91. Lead sulfide + iron: _____ + _____ → _____ + _____

92. Zinc + lead nitrate: _____ + _____ → _____ + _____

93. Lead nitrate + magnesium chloride: _____ + _____ → _____ + _____

94. Lead acetate + hydrogen chloride: _____ + _____ → _____ + _____

95. Ferrous chloride + ammonium hydroxide: _____ + _____ → _____ + _____

96. Potassium sulfide + nitric acid: _____ + _____ → _____ + _____

97. Ammonium oxalate + stannic acetate: _____ + _____ → _____ + _____

98. Calcium phosphate + sulfuric acid: _____ + _____ → _____ + _____

99. Ferrous sulfide + sulfuric acid: _____ + _____ → _____ + _____

100. Ferrous chloride + sodium phosphate: _____ + _____ → _____ + _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 14

ACIDS: THEIR CHARACTERISTIC PROPERTIES

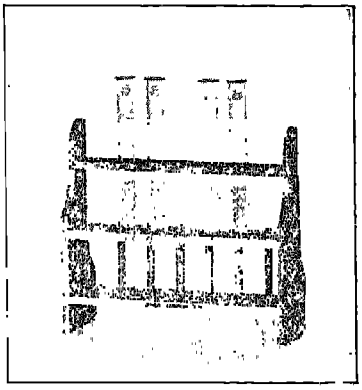
MATERIALS: Concentrated solutions of acetic acid, hydrochloric acid, nitric acid, and sulfuric acid; cupric oxide; magnesium ribbon.

APPARATUS: 4 test tubes; test-tube rack; litmus paper; glass stirring rod.

Great care should be taken in handling acids. Some of them turn the skin yellow, others produce severe burns and destroy clothing. When chemicals are spilled on the desk, they should be cleaned up immediately to prevent needless injury to the skin and clothing.

A. TASTE.

1. Place 4 test tubes in the rack.
2. Pour 10 ml. of water into each tube.
3. Pour 5 drops of acetic into the first tube,
   3 drops of hydrochloric acid into the second tube,
   3 drops of nitric acid into the third tube, and
   2 drops of sulfuric acid into the fourth tube.
4. Thoroughly mix the contents of the first tube with a glass rod. Now remove a drop of this solution and taste it.
5. Taste each of the other solutions. Wash the glass rod and dry it before each test. Record your results in the table.



B. EFFECT ON LITMUS.

1. Use the dilute acid solutions prepared in "A."
2. Use the glass rod to place a drop of the solution from the first test tube on a piece of each kind of litmus paper.
3. Wash the rod and test the reaction of each of the other acid solutions in the same manner. Record the results.

C. ACTION ON METALS.

1. Place 4 clean test tubes in the rack.
2. Pour 5 ml. of water into each tube.
3. Pour 3 ml. of acetic acid into the first tube,
   1 ml. of hydrochloric acid into the second tube,
   1 ml. of nitric acid into the third tube, and
   1 ml. of sulfuric acid into the fourth tube.
4. Drop a small piece of magnesium ribbon, 1 cm. long, into each of the tubes. Observe whether there is a reaction, and immediately
5. Test for hydrogen. Record the results in the table.

D. ACTION ON METALLIC OXIDES.

1. Pour ¼ of a level teaspoon of cupric oxide, CuO, into a test tube.
2. Add 2 ml. of water and 4 ml. of nitric acid.
3. Carefully warm the chemicals for a few minutes. Observe whether there is evidence of a chemical change.
4. Let the tube cool and then filter the solution.
5. Pour the filtrate into an evaporating dish and evaporate it to dryness.

E. ACTION ON CARBONATES.

1. *Pour 5 ml. of water into a test tube.*
2. Add 2 ml. of concentrated hydrochloric acid.
3. Drop 2 or 3 small marble chips, $CaCO_3$, into the tube.
4. Thrust a burning splint into the mouth of the tube.

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Acid	Formula	Taste	Effect on litmus	Reacts with metals?	Hydrogen formed?
Acetic					
Hydrochloric					
Nitric					
Sulfuric					

F. OBSERVATIONS.

1. All acids taste -?-. . . . . _____
2. The formula for an acid always begins with -?-. . . . . _____
3. Acids cause litmus to turn -?-. _____
4. The only element present in all acids is -?-. . . . . _____
5. Therefore, it is the -a- in acids that causes them to taste -b- and to turn litmus -c-. . . . . a. _____ b. _____ c. _____
6. What gas is formed when acids react with metals? . . . . . _____
7. When acids react with metals -?- (class of compounds) are formed. . . . . _____
8. Complete this word equation: . Acid + Metal → _____ + _____
9. Complete and balance: . . . $Mg + HCl \rightarrow$ _____ + _____
10. Complete and balance: . . . $Mg + H_2SO_4 \rightarrow$ _____ + _____
11. Complete and balance: . . . $Mg + HC_2H_3O_2 \rightarrow$ _____ + _____
12. What happened in D-3? . . . _____
13. Complete the word equation for this reaction: . . . . . Acid + Metallic oxide → _____ + _____
14. Complete and balance: . . . $CuO + HNO_3 \rightarrow$ _____ + _____
15. Suggest a name for the solid formed in D-5. . . . . _____
16. What happened in E-4? . . . _____
17. Complete and balance: . . . $HCl + CaCO_3 \rightarrow CaCl_2 + H_2O +$ _____
18. Complete this word equation: Acid + Carbonate → _____ + _____ + _____
19. Therefore, the gas formed in E-4 must have been -?-. . . . . _____
20. When acids react with metals, metallic oxides, and carbonates, -?- (class of compounds) are formed. . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 15

BASES: THEIR CHARACTERISTIC PROPERTIES

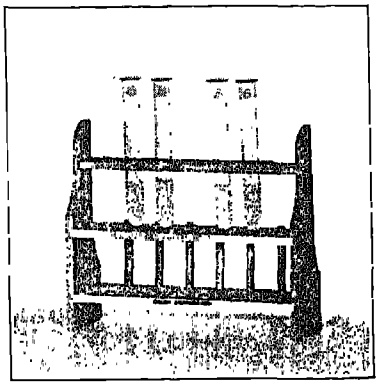
MATERIALS: Solutions of ammonium hydroxide, calcium hydroxide, potassium hydroxide, sodium hydroxide; sodium; calcium oxide; ferric chloride.

APPARATUS: 4 test tubes; test-tube rack; tweezers; filter paper; litmus paper; glass stirring rod.

You will use calcium oxide (lime) in this experiment. It should be freshly prepared for best results. Be very careful when handling sodium. Get it from the instructor only when you are ready to use it. Handle it with tweezers and above all, do not touch it with your hands.

A. PHYSICAL PROPERTIES.

1. TASTE.



a. Place 4 test tubes in the rack.
b. Pour 10 ml. of water into each of the first 3 test tubes.
c. Pour 3 drops of ammonium hydroxide into the 1st,
3 drops of potassium hydroxide into the 2d,
3 drops of sodium hydroxide into the 3d, and
10 ml. of calcium hydroxide into the 4th tube.
d. Place a rubber stopper into the mouth of the first tube and shake it. Now remove a drop of the solution and taste it. If the taste is not distinct add more of the base, a drop at a time, until it is. Rinse your mouth immediately after each test.
e. Taste each of the other solutions. Wash and dry the glass rod and stopper before each test. Record results.

2. EFFECT ON LITMUS.
a. Use the dilute solutions prepared in A-1.
b. Place a drop of each of these solutions on a piece of neutral, or a piece of red and a piece of blue, litmus paper. Wash and dry the rod before each test. Substances which affect litmus in this manner are said to have a "basic reaction."

3. FEEL.
a. Rub a drop of ammonium hydroxide between your fingers and note the characteristic "feel" of bases.
b. Rub a drop of the stock solution of each of the other bases between your fingers. Record the results.

B. PREPARATION.

1. ACTIVE METAL + WATER.
a. Get a piece of sodium, about the size of a grain of rice, from the instructor. Press out the kerosene between a piece of folded filter paper, or a paper towel.
b. Drop the metal into a test tube which is about half full of water.
c. Bring a burning splint to the mouth of the tube.
d. Test the reaction of the solution with litmus paper.

2. METALLIC OXIDE + WATER.
a. Drop a piece of freshly prepared calcium oxide, CaO, into a test tube half full of water.
b. Test the effect of the solution on litmus.

3. PRECIPITATION.
a. Pour 10 ml. of ferric chloride into a test tube.
b. Pour 3 ml. of ammonium hydroxide into the tube.
c. Filter the solution to recover the insoluble base.

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Name of Base	Formula	Taste	Reaction (Effect on Litmus)	Feel
Ammonium hydroxide				
Potassium hydroxide				
Sodium hydroxide				
Calcium hydroxide				

B. OBSERVATIONS.

1. All bases taste -?-. . . . . _____
2. The formula for a base always ends with -?-. . . . . _____
3. Bases turn litmus -?-. . . . . _____
4. How do bases "feel"? . . . . _____
5. In what way is the composition of all bases alike? . . . . . _____
6. Therefore, it is the -a- in bases that causes them to taste -b- and to turn litmus -c-. . . . . a. _____ b. _____ c. _____
7. What is meant by a "basic reaction"? . . . . . _____
8. What happened in B-1c? . . . _____
9. What did this prove? . . . . _____
10. What happened in B-1d? . . _____
11. What did this prove? . . . . _____
12. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____
13. Tell one method for preparing bases. . . . . _____
14. What happened in B-2b? . . _____
15. What did this prove? . . . . _____
16. Write an equation for this reaction. . . . . _____ + _____ → _____
17. Name a second method for preparing bases. . . . . _____
18. What happened in B-3b? . . _____
19. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____
20. Give a third method for preparing bases. . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 16

ANHYDRIDES — NEUTRALIZATION

MATERIALS: Sulfur; calcium oxide; hydrochloric acid; sodium hydroxide.

APPARATUS: 1 test tube; test-tube rack; deflagrating spoon; evaporating dish; wide-mouth bottle and rubber stopper to fit; litmus paper; glass tube; ring-stand and ring; burner.

All oxides which will combine with water are called anhydrides. Those oxides which combine with water to form acids, the oxides of non-metals, are called acid anhydrides. Oxides which combine with water to form bases, the oxides of metals, are called basic anhydrides.

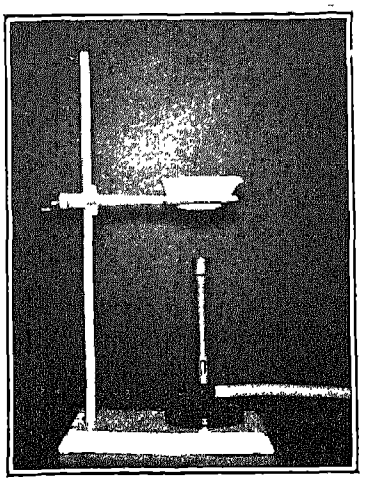
Neutralization is the reaction between an acid and a base to form a salt and water. A salt is a compound which is composed of a metal or a metallic radical plus an acid radical, as NaCl, K_2SO_4, and NH_4NO_3.

A. ANHYDRIDES.

1. Carbon Dioxide, CO_2.
   a. Drop a small piece of neutral litmus paper into a clean, dry test tube.
   b. Pour 10 ml. of water into the tube.
   c. Place a long glass tube into the test tube.
   d. Blow gently through the tube for about a minute so that the exhaled gases bubble through the water.
   e. Observe the litmus paper to see whether it changes color.
2. Sulfur Dioxide, SO_2.
   a. Pour 15 ml. of water into a wide-mouth bottle.
   b. Place a small lump of sulfur into a deflagrating spoon. Ignite the sulfur by holding the spoon in a flame.
   c. Lower the burning sulfur into the bottle and let it remain as long as the sulfur continues to burn.
   d. Remove the spoon. Place a rubber stopper into the mouth of the bottle and shake it violently for a minute.
   e. Test the reaction of the solution with litmus paper.
3. Calcium Oxide, CaO.
   a. Pour about 10 ml. of water into a test tube.
   b. Drop a small lump of calcium oxide into the tube. Let the tube remain in the rack a few minutes, and then
   c. Test the reaction of the solution.

B. NEUTRALIZATION.

1. Prepare 15 ml. of dilute hydrochloric acid (1 : 4). (This means 4 times as much water as acid. The volumes are 3 ml. of acid to 12 ml. of water.)
2. Pour 10 ml. of this dilute acid into an evaporating dish.
3. Pour 10 ml. of sodium hydroxide (10% solution) into the evaporating dish. (A 10% solution consists of 10 grams of solute to 90 grams of solvent; or 10 grams of solute in 100 grams of solution.)
4. Thoroughly mix the acid and base with a glass rod. Test the reaction of the mixture with litmus paper. If the solution is acid, add more of the base, a drop at a time, until it is neutral, i.e., has no effect on litmus paper. If the solution is basic, add more of the acid.
5. Taste a drop of the solution.



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6. Assemble the ring-stand and ring for evaporation. Place a wire gauze under the evaporating dish and evaporate the solution to dryness.

7. Examine and taste the residue.

C. OBSERVATIONS.

1. What is an anhydride? . . . _____

2. What happened in A-1e? . . _____

3. This shows that CO_2 combines with H_2O to form a(n) -?-. . _____

4. Therefore, carbon dioxide is a (n) -?- anhydride. . . . . _____

5. Write an equation for this reaction. . . . . _____ + _____ → _____

6. Write an equation for the burning of sulphur in air. . . . . _____ + _____ → _____

7. What happened in A-2e? . . _____

8. Therefore, SO_2 is a(n) -?- anhydride. . . . . _____

9. Write an equation for this reaction. . . . . _____ + _____ → _____

10. What happened in A-3c? . . _____

11. Therefore, CaO is a(n) -?- anhydride. . . . . _____

12. Write an equation for this reaction. . . . . _____ + _____ → _____

13. What is neutralization? . . . . _____

14. What happened in B-5? . . . _____

15. What happened in B-7? . . . _____

16. Write an equation for this neutralization reaction. . . . . _____ + _____ → _____ + _____

17. How much acid and water are needed to make 45 ml. of dilute sulfuric acid (2 : 7)? . . . . _____

18. How many grams of potassium hydroxide are required to make 80 ml. of a 5% KOH solution? _____

19. Show by an equation whether Na_2O is an acid or a basic anhydride. . . . . _____ + _____ → _____

20. Show by an equation whether SO_3 is an acid or a basic anhydride. . . . . _____ + _____ → _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 17

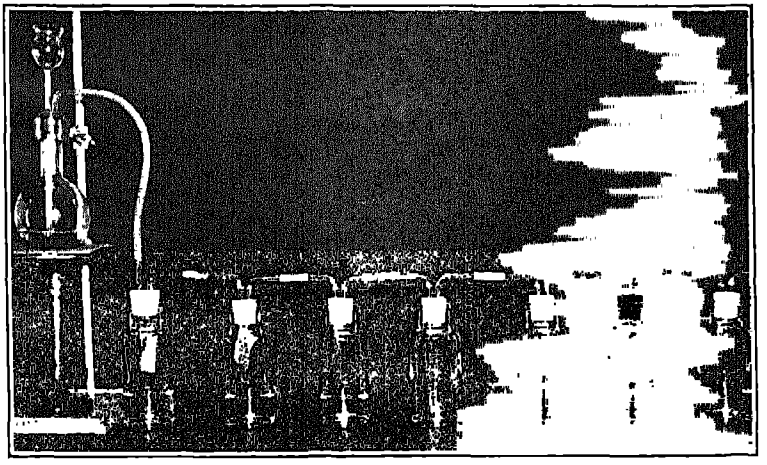
CHLORINE: ITS PREPARATION AND PROPERTIES

MATERIALS: Manganese dioxide; hydrochloric acid; sulfuric acid; sodium hydroxide, 10% solution; sodium; powdered antimony.

APPARATUS: 250 ml. flask; thistle tube; 8 wide-mouth bottles; 7 2-hole rubber stoppers and 1 solid rubber stopper to fit the bottles; ring-stand and ring; wire gauze; test tube clamp; litmus paper; thread; red cotton cloth; compression clamp; beaker; burner.

This experiment may be performed as a demonstration, or by students in groups of 4 or 6. Assemble the apparatus as shown in the picture. Be sure the end of the thistle tube extends nearly to the bottom of the generator. Since chlorine is very poisonous, do not let it escape into the room. Inhaling ammonia or alcohol vapors will counteract some of its effects. Follow instructions precisely.

A. PREPARATION.



1. Remove the stopper and pour a rounded teaspoon of manganese dioxide into the generator.
2. Pour 50 ml. of water into the first bottle, to wash impurities from the gas.
3. Suspend a damp piece of red cloth and a damp piece of litmus paper by a thread over the water in the first bottle.
4. Pour 50 ml. of conc. sulfuric acid into the second bottle. This acts as a dehydrating agent to remove moisture from the gas.
5. Suspend a dry piece of cloth and litmus paper by a thread over the acid in the second bottle.
6. Pour 50 ml. of water into the third bottle. The end of the delivery tube should be about ¼ of an inch ABOVE the water in this bottle.
7. Pour 50 ml. of sodium hydroxide, 10% solution, into the seventh bottle. The excess chlorine combines with the base.
8. Test all connections to see that they fit snugly.
9. Pour 50 ml. of conc. hydrochloric acid through the thistle tube. Shake the flask with a rotary motion to mix the contents.
10. Heat the flask gently to start the action. Do not boil the acid.
11. Follow the gas as it passes from one bottle to another until all are full, then remove the flame.

B. EXPERIMENTATION.

1. Carefully remove the third bottle from the chain. Place a 1-hole rubber stopper in its mouth. Hold your thumb tightly over the hole, and shake the bottle vigorously for a minute. Now hold the bottle mouth downward in water and remove your thumb from over the hole. Observe the results. Repeat several times.
2. Get a piece of sodium, about the size of a grain of rice, from the instructor and place it on a piece of folded filter paper. Fold the paper over the metal and press out the kerosene.
3. Place the sodium in a clean, dry deflagrating spoon and ignite it by holding the spoon over a flame. Quickly lower the burning metal into the fourth bottle. Observe the results. Place a glass plate over the mouth of the bottle and save it until later.

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4. Sprinkle some powdered antimony into the fifth bottle.
5. Light a wax taper or a small candle and lower it into the sixth bottle. Observe the results. Cover its mouth with a glass plate as before.

Reassemble the apparatus. Remove the second bottle from the chain and put an empty bottle in its place. Pour the acid into a beaker on the front desk. See that all parts of the apparatus fit snugly. Now, pour water through the thistle tube until the sixth bottle is full. This forces the gas from the generator and bottles into the base in the seventh bottle. Now the apparatus may safely be taken apart, washed and dried.

C. OBSERVATIONS.

1. Name the chemicals used in the preparation of chlorine. . . _____
2. Write a double replacement equation for this reaction. . . . . _____ + _____ → _____ + _____
3. Equation for the decomposition of manganese tetrachloride. . . _____ → _____ + _____
4. Write the combined equation for this reaction . . . . . _____ + _____ → _____ + _____ + _____
5. Describe the color and odor of chlorine. . . . . _____
6. Why can't chlorine be collected by the displacement of water? . _____
7. What happened in B-1? . . . _____
8. What does this prove? . . . _____
9. What happened in B-3? . . . _____
10. How should the product of B-3 taste? . . . . . _____
11. Write an equation for this reaction. . . . . _____ + _____ → _____
12. What happened in B-4? . . . _____
13. Write an equation for this reaction. . . . . _____ + _____ → _____
14. What happened in B-5? . . . _____
15. Wax is $C_{22}H_{42}$. Suggest a name for the black smoke. . . . . _____
16. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____
17. This shows that chlorine has a strong affinity for -?-. . . . . _____
18. What happened in the first bottle of chlorine? . . . . . _____
19. What happened in the second bottle of chlorine? . . . . . _____
20. What does this prove? . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 18

HYDROGEN CHLORIDE

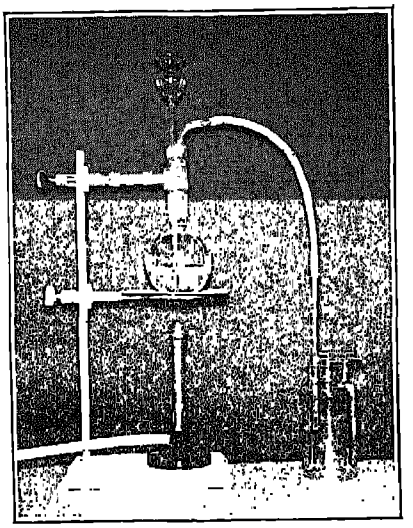
MATERIALS: Sodium chloride; sulfuric acid; ammonium hydroxide.

APPARATUS: 250 ml. flask; thistle tube; 4 wide-mouth bottles; 1 2-hole rubber stopper and 1 solid rubber stopper to fit the bottles; 3 glass cover plates; ring-stand and ring; test-tube clamp; wire gauze; litmus paper; burner; splints.

Be careful not to breathe hydrogen chloride in large amounts as it is very irritating to the nose and throat. Inhaling ammonia will counteract some of its effects. Be very careful in handling concentrated sulfuric acid, as it produces severe skin burns and destroys clothing.

A. PREPARATION.

1. Assemble the apparatus.
2. Pour 2 heaping teaspoons of sodium chloride (salt) into the generator.
3. Pour 30 ml. of dilute sulfuric acid (2 : 1) through the thistle tube. Dilute the acid by cautiously pouring 20 ml. of concentrated sulfuric acid on 10 ml. of water in a small flask or beaker. Cool the mixture under running water before pouring it into the flask.
4. Shake the flask with a rotary motion to mix the chemicals.
5. Heat the generator with a small flame to start the action. Hydrogen chloride is a gas at normal room temperature, so do not increase the size of the flame at any time.
6. Collect 3 bottles of hydrogen chloride by the upward displacement of air. Be sure the collecting bottles are dry. Bring the damp stopper from an ammonium hydroxide bottle over the opening in the stopper. When the bottle is full of gas, white fumes will be formed around the stopper.



7. When one bottle is full, put an empty bottle in its place. Cover the mouth of the bottle with a clean, dry cover glass and place it upright on the desk.
8. After 3 bottles of gas have been collected, pass the gas into a bottle containing 25 ml. of water. The end of the delivery tube should be about 1 cm. above the water in the bottle. Observe the water just below the delivery tube. Pass hydrogen chloride into the water as long as it is evolved. Stopper the bottle and save it for the next experiment.

B. EXPERIMENTATION.

1. Place a bottle of hydrogen chloride mouth downward in water and remove the cover glass. After the action has ceased, replace the cover glass and remove the bottle from the water.
2. Taste a drop of the liquid in this bottle.
3. Test its reaction with litmus paper.
4. Thrust a burning splint into the second bottle of gas.
5. Remove the cover glass from the third bottle and blow your breath across its mouth. Hydrogen chloride is so soluble in water that it causes the moisture from your breath to condense into tiny droplets, forming a fog.
6. Shake an ammonium hydroxide bottle to get some of the base on the stopper. Now, bring the stopper over the mouth of the third bottle of gas. "Sky-writing" and "smoke screens" are made by the use of this compound.

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C. OBSERVATIONS.

1. Name the chemicals used in the preparation of hydrogen chloride. _____
2. Write a double replacement equation for this reaction. . . _____ + _____ → _____ + _____
3. What happened in the generator as it cooled? . . . . . _____
4. What is the name of this substance? (Refer to C-2.) . . . _____
5. Describe the color and odor of hydrogen chloride. . . . . _____
6. What happened in B-1? . . . _____
7. What does this prove? . . . _____
8. What happened in B-2? . . . _____
9. What happened in B-3? . . . _____
10. What do the results of B-2 and B-3 prove? . . . . . _____
11. What is the name of this substance? . . . . . _____
12. What happened in B-4? . . . _____
13. What does this prove? . . . . _____
14. What happened in B-5? . . . _____
15. What caused this to happen? . _____
16. What happened in B-6? . . . _____
17. Suggest a name for the compound formed in B-6. . . . . _____
18. Complete the equation for this reaction. . . . . NH_3 + HCl → _____
19. What happened in the water in A-8? . . . . . _____
20. What does this suggest about the relative densities of these two compounds? . . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 19

HYDROCHLORIC ACID — TEST FOR A CHLORIDE

MATERIALS: Hydrogen chloride solution from Experiment 18; iron filings; zinc; magnesium ribbon; solutions of ammonium hydroxide, silver nitrate, and sodium hydroxide; nitric acid; sodium phosphate; potassium oxalate; sodium chloride.

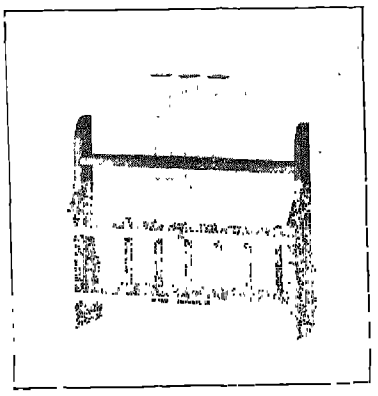
APPARATUS: 5 test tubes; litmus paper.

Hydrochloric acid is a typical acid. Its properties, which will be brought out in this experiment, are characteristic of all acids. Of course, they are more pronounced in some acids than in others. Too, some acids react with metals in a slightly different manner.

A. HYDROCHLORIC ACID.

1. TASTE.

   Add 1 drop of the hydrogen chloride solution, from Experiment 18, to 2 ml. of water in a test tube. Shake the tube to mix the contents. Remove a drop of this solution with a stirring rod and taste it.



2. EFFECT ON LITMUS.

   Test the action of this acid on litmus paper.

3. ACTION ON METALS.

   a. Arrange 3 test tubes in the rack and pour 5 ml. of the solution into each of the tubes.

   b. Drop a small piece of zinc into the first tube, a few iron filings into the second tube, and a 1 cm. length of magnesium ribbon into the third.

   c. Bring a burning splint to the mouth of each tube. If nothing happens, place stoppers LIGHTLY in the mouth of the tubes for a minute, then repeat the test.

4. ACTION ON BASES.

   a. Pour 2 ml. of sodium hydroxide solution into a test tube.

   b. Add the acid solution, a small amount at a time, until the mixture has no effect on litmus paper. Shake the tube after each addition to thoroughly mix the contents before testing its action on litmus.

   c. Taste a drop of this solution.

B. TEST FOR A CHLORIDE.

1. Pour 5 ml. of the acid solution, or any solution which you wish to test, into a test tube.
2. Pour a few drops of silver nitrate solution into the tube.
3. If a precipitate is formed, pour ½ of the solution into another tube. Test the solubility of the precipitate as follows:
   a. Pour 2 ml. of nitric acid into one of the tubes and observe its effect upon the precipitate. Record the results.
   b. Pour 2 ml. of ammonium hydroxide into the other tube and observe its effect upon the precipitate.
4. Test dilute solutions of sodium phosphate, potassium oxalate, and sodium chloride for a chloride. Record the results in the table.
5. Now get an unknown from the instructor and test it for a chloride. Record its number and the results of your test.

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TEST FOR A CHLORIDE

PROCEDURE	HCl	Na_3PO_4	$K_2C_2O_4$	NaCl	Unknown No.
Add $AgNO_3$. If a precipitate is formed, record its color.					
Add HNO_3. Is the precipitate soluble?					
Add NH_4OH. Is the precipitate soluble?					
Is a chloride present?					

C. OBSERVATIONS.

1. Hydrogen chloride is prepared by the reaction between -?-. . . . _____
2. How is hydrochloric acid prepared? . . . . . _____
3. How does HCl taste? . . . . _____
4. How does HCl affect litmus? . _____
5. What happened in A-3c? . . _____
6. What does this prove? . . . _____
7. Complete and balance: . . . Zn + HCl → +
8. Complete and balance: . . . Fe + HCl → +
9. Complete and balance: . . . Mg + HCl → +
10. Complete this word equation: Hydrochloric acid + Metal → +
11. What class of salts is formed when HCl reacts with metals? . _____
12. What happened in A-4c? . . . _____
13. Write an equation for this reaction. . . . . + → +
14. What is this process called? . _____
15. When an acid and a base react, -a- and -b- are formed. . . . a. _____ b. _____
16. What happened in B-2? . . . _____
17. Write an equation for this reaction. . . . . + → +
18. What happened in B-3a? . . . _____
19. What happened in B-3b? . . _____
20. When -a- is added to a chloride, a white ppt. is formed which is -b- in HNO_3 and -c- in NH_4OH. a. _____ b. _____ c. _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 20

THE ELECTROCHEMICAL SERIES

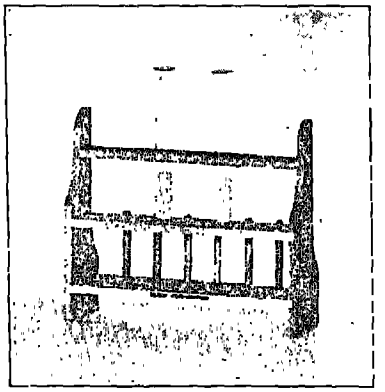
MATERIALS: Dilute solutions of lead nitrate, mercuric chloride, silver nitrate, zinc nitrate, cupric sulfate; sulfuric acid; 1 copper strip; 1 zinc strip. The metal strips should be about 1 cm. wide and 20 cm. long.

APPARATUS: 2 test tubes; test-tube rack; emery paper.

The electrochemical series is frequently called the electromotive series or the replacement series. It is a list of metals arranged in the order of their decreasing activity. Single replacement reactions will take place if the free metal is more active, higher in the electrochemical series, than the combined metal. Of course, if a salt is insoluble it cannot ionize and no reaction will take place.

A. EXPERIMENTATION.

1. Polish (emery) a zinc strip until it is bright and shiny. Clean a copper strip in the same way.
2. Place 2 test tubes in the rack.
3. Pour 5 ml. of lead nitrate into each tube.
4. Lower the zinc strip into one of the tubes. After a few seconds, examine both the metal and the solution for evidence of a chemical change. Wipe the metal strip on a piece of white filter paper for more exacting proof of a reaction. Finely divided metals are usually dark gray or black. Record the results under "Evidence of Reaction" on line 1, in the table below.
5. Repeat A-4, using the copper strip and the other test tube of lead nitrate. Record the results on line 7. If there is no evidence of a reaction either on the metal or in the solution, write "no reaction" in the proper place.



B. Repeat A, using a mercuric chloride solution.

C. Repeat A, using a silver nitrate solution.

D. Repeat A, using a zinc nitrate solution.

E. Repeat A, using a cupric sulfate solution.

F. Repeat A, using sulfuric acid (1 : 9).

Metal		Evidence of Reaction	Solution	Evidence of Reaction	Metal	
1	Zn		$Pb(NO_3)_2$		Cu	7
2	Zn		$HgCl_2$		Cu	8
3	Zn		$AgNO_3$		Cu	9
4	Zn		$Zn(NO_3)_2$		Cu	10
5	Zn		$CuSO_4$		Cu	11
6	Zn		H_2SO_4		Cu	12

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G. OBSERVATIONS.

Write ionic equations for each of the reactions indicated by the table on the preceding page. If no reaction takes place, write "no reaction." As an explanation of why the reaction did or did not take place, write the electrochemical series number beneath the symbol for each of the reacting metallic elements.

EXAMPLE: Fe° (12) + Cu^{+2} (22) + SO_4^{-2} → Fe^{+2} + SO_4^{-2} + Cu°

1. ____ + ____ + ____ → ____ + ____ + ____

2. ____ + ____ + ____ → ____ + ____ + ____

3. ____ + ____ + ____ → ____ + ____ + ____

4. ____ + ____ + ____ → ____ + ____ + ____

5. ____ + ____ + ____ → ____ + ____ + ____

6. ____ + ____ + ____ → ____ + ____ + ____

7. ____ + ____ + ____ → ____ + ____ + ____

8. ____ + ____ + ____ → ____ + ____ + ____

9. ____ + ____ + ____ → ____ + ____ + ____

10. ____ + ____ + ____ → ____ + ____ + ____

11. ____ + ____ + ____ → ____ + ____ + ____

12. ____ + ____ + ____ → ____ + ____ + ____

13. What is the appearance of the deposited metals? . . . . . ____

14. How do copper and zinc compare in their ability to replace other metals from their compounds? . ____

15. Make a replacement series of the metallic elements used in this experiment. . . . . ____

16. Give the two other names for the "electrochemical series." . . ____

17. In order for a single replacement reaction to take place, the compound must be -?-. . . . . ____

18. In order for a single replacement reaction to take place, the free metal must be -?-. . . . . ____

19. Why are free elements shown to have no valence, as Cu°? . . . ____

20. What does Zn^{+2} mean in terms of electrons? . . . . . ____

DATE..... PERIOD..... NAME.....

EXPERIMENT 21

DOUBLE REPLACEMENT REACTIONS

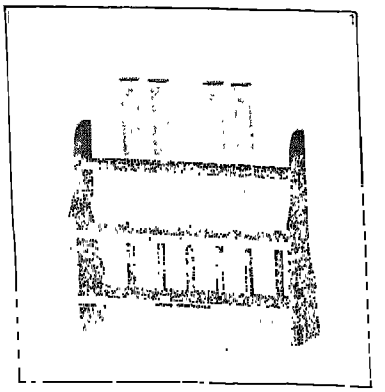
MATERIALS: Ammonium chloride; hydrochloric acid; solutions of silver nitrate, barium chloride, cupric sulfate, zinc nitrate, sodium phosphate, sodium carbonate, sodium chloride, sodium hydroxide; litmus solution.

APPARATUS: 4 test tubes; beaker, 150 ml.

The reaction between two compounds is called a double replacement reaction. Double replacement reactions take place if both of the reacting compounds are soluble. There are two kinds of double replacement reactions, those which go to completion (completion reactions) and those which are reversible (reversible reactions). All double replacement reactions are reversible unless at least one of the products is insoluble (precipitate), un-ionized (water), or a gas which is allowed to escape from the field of action.

A. EXPERIMENTATION.

1. Drop a few crystals of sodium chloride into a test tube containing 5 ml. of water. Shake the tube to dissolve the salt. Now add about 2 ml. of silver nitrate solution.
2. Pour about 5 ml. each of barium chloride and sodium phosphate into a test tube. Observe the results.
3. Pour ¼ of a teaspoon of solid ammonium chloride into a test tube. Add a few drops of sodium hydroxide solution. Feel the bottom of the tube to see whether there is any temperature change. Warm the bottom of the tube by holding it in the palm of your hand for a minute or two. Smell at the mouth of the tube at frequent intervals while you are warming it, to see whether you can identify the escaping gas by its odor.



4. Pour 5 ml. of sodium carbonate solution into a test tube. Cautiously add dilute hydrochloric acid (1 : 9) in small amounts. Test for the presence of a gas by thrusting a burning splint into the mouth of the tube.
5. Pour 5 ml. of sodium hydroxide into a small beaker. Dilute the base with 25 ml. of water. Place the beaker on a piece of white filter paper, and add 2 or 3 drops of phenolphthalein, an indicator. Now add dilute hydrochloric acid (1 : 5), a little at a time with constant stirring, until the last drop completely neutralizes the solution—that is, causes the solution to become colorless. Feel the sides of the beaker to see whether you can detect any temperature change. Taste a drop of the solution.
6. Pour equal volumes (about 5 ml.) of barium chloride and zinc nitrate into a test tube. Test for evidence of a reaction.
7. Pour about 5 ml. each of sodium chloride and cupric sulfate solution into a test tube. Test for evidence of a reaction.

B. OBSERVATIONS.

1. Double replacement reactions are reactions between -?-. . . . . _____
2. The two kinds of double replacement reactions are -?-. . . . _____
3. Double replacement reactions take place if -?-. . . . . _____

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4. Double replacement reactions are reversible unless -?-. . . . . _____

5. Double replacement reactions go to completion if -?-. . . . . _____

6. What happened in A-1? . . . _____

7. Does this indicate a completion or a reversible reaction? . . . _____

8. What happened in A-2? . . . _____

9. What temperature change took place in A-3? . . . . . _____

10. What happened in A-3? . . . _____

11. What happened in A-4? . . . _____

12. What does this prove? . . . _____

13. What temperature change took place in A-5? . . . . . _____

14. What was the taste of the liquid? _____

15. What evidence is there (if any) that a reaction took place in A-5? _____

16. What happened in A-6? . . . _____

17. What evidence is there (if any) that a reaction took place in A-6? _____

18. All neutralization reactions go to completion because -?-. . . . _____

Write equations for the reactions as indicated. Show whether each reaction is reversible or completion. Make use of the following symbols: . . . . . .

$\rightarrow$ . . completion reaction
$\rightleftarrows$ . . reversible reaction
( ) . . un-ionized compound
$\downarrow$ . . precipitate
$\uparrow$ . . gas

19. A-1: _____

20. A-2: _____

21. A-3: _____

22. A-4: _____

23. A-5: _____

24. A-6: _____

25. A-7: _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 22

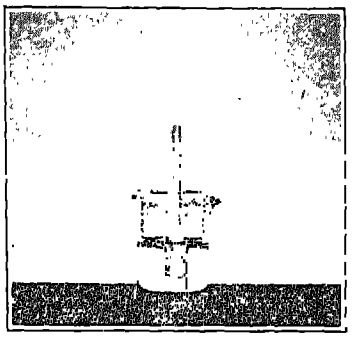
NITROGEN: ITS PREPARATION AND PROPERTIES

MATERIALS: Phosphorus; ammonium chloride; sodium nitrite; limewater.

APPARATUS: Flask, 250 ml.; thistle tube; pneumatic trough; 3 wide-mouth bottles; 2 glass cover plates; test tube, Pyrex or hard glass beaker; ring-stand and ring; test-tube clamp; wire gauze; knitting needle, or wire; wood splints; watch glass; burner.

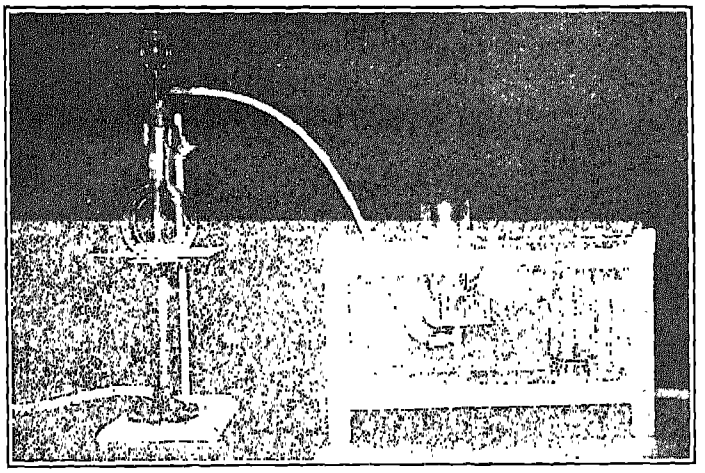
A. PREPARATION.

1. PREPARATION FROM AIR.



a. Get a piece of yellow phosphorus, about the size of a grain of rice, from the instructor.
b. Drop the metal into the test tube. If the metal does not adhere to the bottom of the tube and remain in place when the tube is carefully inverted, add a drop of water and try again.
c. Ignite the phosphorus by touching it with a warm knitting needle or wire.
d. Immediately place the tube mouth-downward in a beaker which is about ½ full of water.
e. Let the tube remain in the beaker until the white cloud, phosphorus pentoxide, P_2O_5, has dissolved in the water.

2. PREPARATION FROM AMMONIUM NITRITE.



Assemble the apparatus as shown. Nitrogen can be obtained by heating ammonium nitrite, but the reaction takes place too fast. We will heat a mixture of sodium nitrite and ammonium chloride to form ammonium nitrite which will decompose, as it is formed, into nitrogen and water.

a. Pour 5 grams of ammonium chloride and 7 grams of sodium nitrite, a well rounded teaspoon of each, into a flask.
b. Add 50 ml. of water and shake the flask to dissolve the chemicals.
c. Heat the flask very gently. Remove the flame as soon as the action begins. If the action becomes too vigorous, pour a little water through the thistle tube to reduce the temperature.
d. Collect 3 bottles of nitrogen by the displacement of water. Discard the first bottle of gas.
e. Place a cover glass over the mouth of each bottle, remove it from the trough and place it mouth-downward on the desk.

B. EXPERIMENTATION.

1. Adjust the test tube, from A-1e, so the level of the water is the same on the inside and outside of the tube. Measure the length of the tube and the height of the water in the tube.
2. Thrust a burning splint into the mouth of one of the bottles of nitrogen. Observe whether nitrogen is combustible or supports combustion.
3. Pour 10 ml. of limewater into a bottle of nitrogen. Shake the bottle, and observe any change in its appearance.

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4. Place a few drops of the solution from the flask on a clean watch glass and evaporate it to dryness on a water bath. Taste a crystal of the residue.

C. OBSERVATIONS.

1. What is the name of the white cloud formed in A-1c? . . . _____
2. Write an equation for the reaction in A-1c. . . . . _____ + _____ → _____
3. What fractional part of the tube filled with water, in B-1? . . _____
4. Why did the water rise in the tube? . . . . . _____
5. What gas does the test tube contain? . . . . . _____
6. This experiment proves that air is composed of -?-. . . . . _____ % and _____ %
7. Why is it that pure nitrogen cannot be prepared by this method? _____
8. Write an equation for the reaction which took place when P_2O_5, the anhydride of phosphoric acid, combined with water. . . . . _____ + _____ → _____
9. Why isn't nitrogen prepared directly by the decomposition of ammonium nitrite? . . . . _____
10. Write an equation for the double replacement reaction which took place in A-2c. . . . . _____ + _____ → _____ + _____
11. Write an equation for the decomposition reaction which took place in A-2c. . . . . _____ → _____ + _____
12. Which property of nitrogen is shown by the method by which it is collected? . . . . . _____
13. Why was the first bottle of nitrogen discarded? . . . . . _____
14. Which property of nitrogen is shown by the procedure in A-2e? _____
15. Describe the color and odor of nitrogen. . . . . _____
16. What did you prove by the results of B-2? . . . . . _____
17. What happened in B-3? . . . _____
18. How could you distinguish between a bottle of nitrogen and a bottle of carbon dioxide? . . _____
19. How did a crystal of the residue from B-4 taste? . . . . . _____
20. What is the name of this compound? (Refer to C-10 & 19.) . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 23

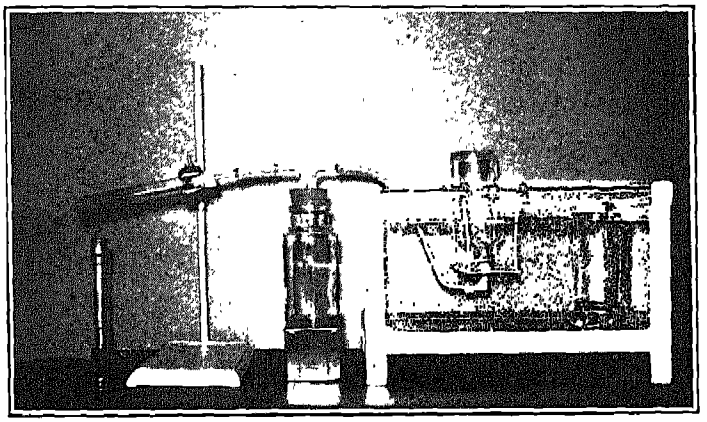
NITROUS OXIDE

MATERIALS: Ammonium nitrate; sulfur.

APPARATUS: Test tube, Pyrex or ignition; delivery tube; 5 wide-mouth bottles; 1-hole rubber stopper to fit the bottles; 4 glass cover plates; pneumatic trough; deflagrating spoon; wood splints.

Nitrous oxide, N_2O, is frequently called "laughing gas." When inhaled, small amounts produce hysteria and larger amounts produce unconsciousness. It is used as an anesthetic in minor surgical operations and in dentistry. Nitrous oxide is stable at room temperature, but at slightly higher temperatures it decomposes into nitrogen and oxygen.

A. PREPARATION.



1. Pour about 10 grams, a heaping teaspoon, of ammonium nitrate into a Pyrex, or ignition, test tube.
2. Assemble the apparatus as illustrated.
3. Heat the tube gently until the nitrate melts and begins to boil. Be careful not to heat the compound too intensely because explosive gases may be formed.
4. Collect 4 bottles of nitrous oxide by the displacement of, preferably warm, water. Cover the mouth of each bottle, as it becomes filled with gas, and place it upright on the desk.
5. Discard the first bottle of gas collected.

B. EXPERIMENTATION.

1. Observe the color and odor of nitrous oxide.
2. Pour 25 ml. of cold water into one of the bottles of gas. Place a 1-hole rubber stopper into the mouth of the bottle. Place your finger over the hole in the stopper and shake the bottle vigorously. Now place the bottle mouth-downward in cold water and remove your finger from over the hole in the stopper. Observe the results.
3. Thrust a glowing splint into a bottle of the gas. Repeat several times so you are sure of the results.

4a. Heat a small lump of sulfur in a deflagrating spoon until it just begins to burn. Immediately lower the feebly burning sulfur into a bottle of nitrous oxide. Observe whether the sulfur continues to burn. Remove the spoon and cover the mouth of the bottle.

b. Heat the sulfur again until it burns vigorously. Lower this actively burning sulfur into the same bottle of gas. Observe the results this time.

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C. OBSERVATIONS.

1. What is the common name for nitrous oxide? . . . . . _____
2. When inhaled, small amounts of nitrous oxide produce -?-. . . _____
3. When inhaled, large amounts of nitrous oxide produce -?-. . . _____
4. Name one purpose for which nitrous oxide is used. . . . . _____
5. Write an equation for the reaction which took place in A-3. . _____ → _____ + _____
6. What is the name of this type of reaction? . . . . . _____
7. What substance was collected in the "trap bottle"? Refer to C-5 _____
8. Why was the first bottle of gas discarded? . . . . . _____
9. Describe the color and odor of nitrous oxide. . . . . _____
10. What happened in B-2? . . . _____
11. What does this prove? . . . _____
12. Why should nitrous oxide be collected by the displacement of warm water? . . . . . _____
13. What happened in B-3? . . . _____
14. What gas must have been present to cause this action? . . . . _____
15. What must have happened to the nitrous oxide? . . . . . _____
16. Write an equation for this change. . . . . _____ → _____ + _____
17. What happened in B-4a? . . _____
18. What happened in B-4b? . . . _____
19. Explain this difference in action. _____
20. How could you distinguish between a bottle of oxygen and a bottle of nitrous oxide? . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 24

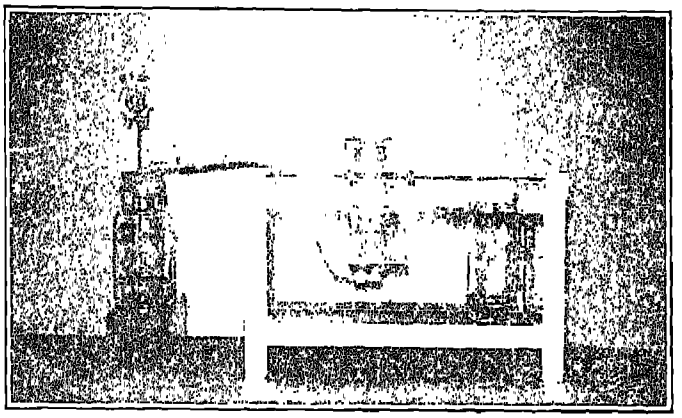
NITRIC OXIDE — NITROGEN DIOXIDE

MATERIALS: Copper shot, or turnings; nitric acid; red phosphorus.

APPARATUS: 4 wide-mouth bottles; 1 2-hole rubber stopper and 1 1-hole rubber stopper to fit the bottles; 2 glass cover plates; thistle tube; pneumatic trough; deflagrating spoon; test tube; wood splints.

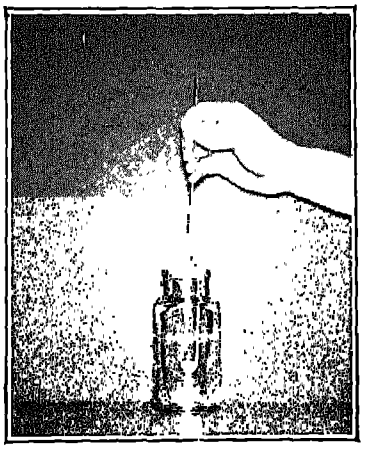
Nitric oxide, NO, is formed when dilute nitric acid reacts with metals. It is a decomposition product of nitric acid. Nitrogen dioxide, NO_2, is formed when concentrated nitric acid reacts with metals or when nitric oxide is exposed to air or oxygen. Both of these gases are poisonous, so be very careful not to inhale them.

A. PREPARATION.



1. Pour about 10 grams, 1 teaspoon, of copper shot, or turnings, into one of the wide-mouth bottles.
2. Assemble the apparatus as illustrated.
3. Pour about 20 ml. of water into the thistle tube.
4. Pour nitric acid through the thistle tube, in small amounts, to maintain a steady flow of gas.
5. Collect 2 bottles of nitric oxide by the displacement of water. Slip a cover glass over the mouth of each bottle; remove the bottles from the trough and place them mouth-upward on the desk.
6. Fill a bottle 2/3 full of nitric oxide. Insert a 1-hole stopper into the mouth of the bottle, while still under water. Keep your thumb over the hole in the stopper while you are removing the bottle from the trough.

B. EXPERIMENTATION.



1. Observe the color of nitric oxide.
2. Shake the bottle from A-6 vigorously. Invert the bottle in the trough and remove your thumb from over the hole.
3. Place the bottle upright on the desk and remove the stopper.

4a. Replace the stopper and shake the bottle vigorously. Note the results.

b. Now remove your thumb from the stopper for a moment. Replace your thumb over the hole and shake the bottle. Repeat this as long as the action continues to take place.

5. Test the liquid in the bottle with litmus paper.
6. Slip the cover glass from the mouth of one of the bottles and quickly thrust a burning splint into the nitric oxide. Replace the cover glass immediately after making the test.
7. Heat a small piece of red phosphorus in a deflagrating spoon until it begins to burn. Lower the spoon into the second bottle of gas.
8. Pour about 3 ml. of concentrated nitric acid into a test tube. Drop 3 or 4 copper shot or turnings into the acid. Thrust a glowing splint into the tube. Repeat this test several times.
9. Empty the bottles of gas by holding them mouth-downward out the window or under the hood.

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Comparison of:	Nitrous Oxide	Nitric Oxide	Nitrogen Dioxide
Formula			
Color			
Burning splint			
Relative stability			
Relative solubility			

C. OBSERVATIONS.

1. What gas is formed when dilute nitric acid reacts with metals? . _____
2. What gas is formed when conc. nitric acid reacts with metals? . _____
3. What happened in B-2? . . . _____
4. What does this prove? . . . _____
5. What happened in B-3? . . . _____
6. What is the name of this gas? . _____
7. Write an equation for the formation of this gas. . . . . _____ + _____ → _____
8. What happened in B-4a? . . . _____
9. What did this prove? . . . . _____
10. What happened in B-5? . . . _____
11. What does this prove? . . . _____
12. Write an equation for the reaction which occurred in B-4. . . _____ + _____ → _____ + NO
13. What happened in B-6? . . . _____
14. What happened in B-7? . . . _____
15. What gas must have been present to cause this action? . . . . _____
16. Explain why the results of B-6 & B-7 were different. . . . . _____
17. Write an equation for the decomposition in B-7. . . . . _____ → _____ + _____
18. What gas was formed in B-8? . _____
19. What happened in B-8? . . . _____
20. Write an equation for this decomposition reaction. . . . _____ → _____ + _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 25

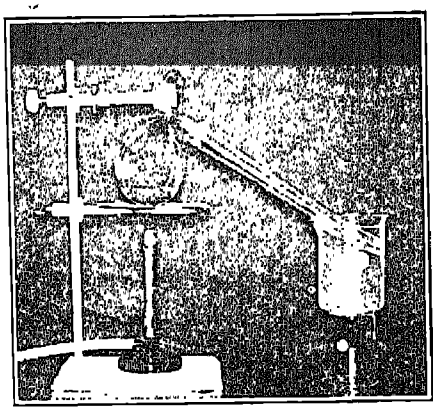
NITRIC ACID

MATERIALS: Sodium nitrate; sulfuric acid; ferrous sulfate, saturated solution; copper; zinc; egg albumen.

APPARATUS: Retort; glass funnel; beaker, 400 ml.; watch glass; 5 test tubes; test-tube rack; ring-stand and ring; wire gauze; burner; wood splints; litmus paper.

Nitric acid is the most important acid containing nitrogen. When pure, nitric acid is a colorless liquid, but it is frequently colored yellow by nitrogen dioxide, a decomposition product. Both nitric acid and sulfuric acid are very corrosive, so be very careful not to get them on the hands or clothing.

A. PREPARATION.



1. Pour about 12 grams, 1 heaping teaspoon, of sodium nitrate through a paper funnel into the retort.
2. Pour 10 ml. of concentrated sulfuric acid through a glass funnel into the retort.
3. Assemble the apparatus as shown in the diagram. Place the retort on a wire gauze. The neck of the retort should fit loosely into the mouth of a test tube which is partly immersed in a beaker of water.
4. Gently heat the retort with a small flame. Brown fumes indicate a too high temperature.
5. Continue heating the retort gently until all of the nitric acid has distilled over.

B. EXPERIMENTATION.

1. Pour 10 ml. of water into a test tube. Add 1 drop of the nitric acid which you have just prepared. Test with litmus paper.
2. Put a few crystals of egg albumen, or a small piece of cooked egg white, in a watch glass. Place a drop of nitric acid on this protein. Nitric acid would have the same effect on your skin or any other protein.
3. Pour 2 ml. of nitric acid into a test tube and heat it gently. Thrust a glowing splint into the mouth of the tube.
4. Drop 2 or 3 copper shot, or turnings, into a test tube and add 1 ml. of nitric acid. Test the evolved gas with a glowing splint.
5. Drop 2 or 3 copper shot, or turnings, into a test tube and add 2 ml. of dilute nitric acid (1 : 3). Test the evolved gas with a glowing splint.
6. Drop a small piece of zinc into a test tube and add 2 ml. of nitric acid (1 : 3). Test for hydrogen, with a burning splint.
7. Observe the compound in the retort. Pour about 100 ml. of warm water into the retort and shake it with a rotary motion. Discard the solution. Wash the retort and return it to the stock room.
8. Test for a Nitrate.
   a. Pour a few drops of the dilute nitric acid solution, from B-1, into a test tube.
   b. Add 5 ml. of freshly prepared ferrous sulfate (or ferrous ammonium sulfate) solution.
   c. Incline the tube and carefully pour 3 ml. of concentrated sulfuric acid down the side of the tube, so the chemicals do not mix.
   d. Let the tube stand in the rack for a few minutes. Observe the positive test for a nitrate.
9. Repeat this test for a nitrate, using a few drops of sodium nitrate solution instead of the dilute nitric acid.

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C. OBSERVATIONS.

1. Write an equation for the preparation of nitric acid. . . . . + → $NaHSO_4$ +

2. What happened in B-1? . . .

3. What happened in B-2? . . .

4. What happened in B-3? . . .

5. What does this prove? . . .

6. Write an equation for this decomposition reaction. . . . . → + +

7. What happened in B-4? . . .

8. What gas is evolved when copper reacts with conc. nitric acid? .

9. Write an equation for this reaction. . . . . + → + +

10. What happened in B-5? . . .

11. What gas is evolved when copper reacts with dilute nitric acid? .

12. Write an equation for this reaction. . . . . + → + +

13. Copper cannot replace hydrogen from acids because -?-. . . .

14. Copper reacts with nitric acid because this acid is a(n) -?-. . .

15. How could nitric acid be used to distinguish between gold and copper or brass? . . . . .

16. What happened in B-6? . . .

17. Hydrogen was not given off because -?-. . . . . .

18. Write an equation for this reaction. . . . . + → + +

19. Zinc can replace hydrogen from acids because -?-. . . . . .

20. Nitrate Test: Pour a few drops of the unknown into a test tube, add 5 ml. of -a- and carefully pour 3 ml. of -b- down the side of the tube. If a nitrate is present -c- will be formed. . . . . a. b. c.

DATE..... PERIOD..... NAME.....

EXPERIMENT 26

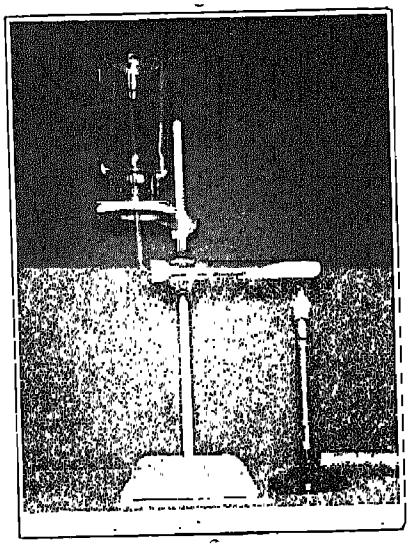
AMMONIA

MATERIALS: Ammonium chloride; ammonium sulfate; calcium hydroxide; sodium hydroxide solution; hydrochloric acid.

APPARATUS: 2 test tubes, with a 1-hole cork stopper to fit; 4 wide-mouth bottles; 3 cover glasses; ring-stand; test tube clamp; glass delivery tube; pneumatic trough; litmus paper.

Ammonia, NH_3, is one of the most important compounds of nitrogen. It is easily recognized by its sharp, penetrating odor. Pure ammonia is very poisonous, and even when diluted with air it is very irritating to the lining of the nose and throat, so be very careful not to breathe any more of the gas than is necessary.

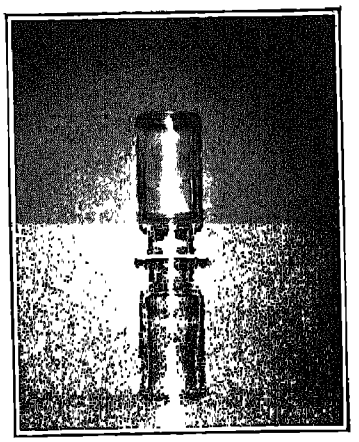
A. PREPARATION.



1. Pour about 7 grams of ammonium chloride and 6 grams of calcium hydroxide, 1 well-rounded teaspoon of each, on a piece of paper and mix thoroughly. Pour this mixture into the test-tube generator.
2. Assemble the apparatus. The delivery tube should extend nearly to the bottom of the collecting bottle.
3. Heat the mixture gently by moving a small flame back and forth under the tube.
4. Collect 3 bottles of ammonia by the downward displacement of air. (Be sure the bottles and cover glasses are dry.) Moisten a piece of red and a piece of blue litmus paper and hold them over the mouth of the bottle. When the bottle is full, the litmus paper will change color.
5. Slip a dry cover glass over the mouth of each bottle, as it is filled, and place it mouth-downward on the desk.

B. EXPERIMENTATION.

1. Fill the pneumatic trough about ¼ full of water. Place a bottle of ammonia mouth-downward in the water and remove the cover glass. After about 5 minutes, observe the results.
2. Replace the cover glass; remove the bottle from the trough and place it upright on the desk. Test the effect of the liquid in the bottle on litmus paper.
3. Pour some of the liquid from this bottle into a test tube. Heat the tube and cautiously test the odor of the escaping gas.
4. Lift a bottle of ammonia from the desk, mouth-downward, and thrust a burning splint into the gas. Observe whether ammonia is combustible or supports combustion.
5. Warm a clean, dry wide-mouth bottle by holding it above a flame for a few moments. Pour a few drops of hydrochloric acid into the bottle and rotate it to spread the acid on the bottom and sides. Place a cover glass over the mouth of the bottle and invert it over a bottle of ammonia; remove both cover glasses.
6. Place a few crystals of ammonium chloride and an equal bulk of calcium hydroxide, in separate piles, in the palm of your hand. Test the odor of each compound.
7. Rub the compounds together. Test the odor of the mixture.
8. Hold a piece of moist litmus paper over the mixture.



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9. Test for an Ammonium Compound.
   a. Place a few crystals of ammonium chloride in a test tube.
   b. Add a few drops of sodium hydroxide solution.
   c. Heat gently. Cautiously test the odor of the escaping gas.
10. Repeat this test, using ammonium sulfate instead of ammonium chloride.

C. OBSERVATIONS.

1. Write an equation for the preparation of ammonia. . . . . + → + +
2. What does A-5 suggest about the relative densities of ammonia and air? . . . . . _____
3. What happened in B-1? . . . _____
4. What does this prove? . . . _____
5. What happened in B-2? . . . _____
6. What does this prove? . . . _____
7. Write an equation for this reaction. . . . . + →
8. What happened in B-3? . . . _____
9. Which property of ammonium hydroxide does this illustrate? . _____
10. Write an equation for this reaction. . . . . → +
11. What happened in B-4? . . . _____
12. What does this prove? . . . _____
13. What happened in B-5? . . . _____
14. Write an equation for this reaction. . . . . + →
15. Give the results of B-6. . . . _____
16. Give the results of B-7. . . . _____
17. What happened in B-8? . . . _____
18. Write an equation for this reaction. . . . . + → + +
19. What happened in B-9? . . . _____
20. Test for ammonium compounds: Add a few drops of -a- to the unknown; warm the mixture gently. If an ammonium compound is present, -b- will be formed, which you can detect by its -c-. . . . a. _____ b. _____ c. _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 27

SULFUR

MATERIALS: Powdered roll sulfur; flowers of sulfur; copper wire or foil; carbon disulfide; zinc dust.

APPARATUS: Watch glass; magnifying glass; beaker; funnel; 2 test tubes; deflagrating spoon; filter paper; asbestos mat; tweezers.

Pure sulfur is a tasteless and odorless yellow solid (roll sulfur) or powder (flowers of sulfur). Its three allotropic forms are rhombic, prismatic (or monoclinic) and plastic (or amorphous) sulfur. The prismatic and plastic allotropes are unstable and gradually change into rhombic sulfur, the most stable form.

A. PHYSICAL PROPERTIES.

1. RHOMBIC SULFUR.
   a. Pour about 0.1 gram, ¼ level teaspoon, of powdered roll sulfur into a test tube.
   b. Add 5 ml. of carbon disulfide. Stopper and shake the tube until the sulfur dissolves. Carbon disulfide is both poisonous and inflammable so keep it away from the flame.
   c. Filter the solution into a watch glass. Cover the watch glass with a piece of filter paper and place it under the hood or on the window sill. Continue with the next part of the experiment while you are waiting for the solvent to evaporate.
   d. Examine the residue (rhombic sulfur) under a magnifying glass, and draw a few of the crystals in the space at the right.

2. PRISMATIC SULFUR.
   a. Pour a heaping teaspoon of powdered roll sulfur or flowers of sulfur into a test tube.
   b. Carefully melt the sulfur by rotating the tube about 3 inches above a small flame. A brown color indicates too high a temperature.
   c. Pour the liquid sulfur into the cone of a folded filter paper. As soon as a few crystals have formed at the edge of the cone, pour the remaining liquid into a beaker of cold water.
   d. Immediately unfold the filter paper and examine the prismatic sulfur under a magnifying glass.
   e. Draw a few of the crystals in the space at the right.

3. PLASTIC SULFUR.
   a. Pour a heaping teaspoon of powdered sulfur into a test tube, the same one used in A-2.
   b. Carefully heat the sulfur until it just begins to boil. Tilt the tube occasionally and carefully observe the changes in color and consistency of the sulfur as the temperature rises.
   c. Hold the tube at arm's length; slowly pour the molten sulfur, in a fine stream, into a large beaker of cold water.
   d. Remove the plastic sulfur from the water and observe its properties (color, structure, hardness, elasticity).
   e. Draw a piece of plastic sulfur in the space at the right.

B. CHEMICAL PROPERTIES.

1. Test the solubility of rhombic, prismatic, and plastic sulfur in carbon disulfide.
2. Burn a small piece of each of the allotropes of sulfur in a deflagrating spoon. Record the results in each case.
3. Warm a dime in the flame. Rub a little sulfur on the silver coin.

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4. Heat the test tube which was used in A-3 until the sulfur begins to boil and the tube is filled with sulfur vapors. Thrust a piece of hot copper wire or foil into the tube. Observe the evidence of a chemical change.

5. Mix ½ of a level teaspoon each of zinc dust and powdered sulfur on a piece of filter paper. Pour the mixture on an asbestos mat, which rests on the base of your ring-stand, so as to form a little mound. Heat the mixture, at arm's length, with the tip of a Bunsen flame.

C. OBSERVATIONS.

	Comparison of:	Rhombic	Prismatic	Plastic
1.	Color			
2.	Structure			
3.	Solubility in CS_2			
4.	Color of flame			
5.	Odor of product			

6. What was the color of the liquid sulfur in A-2b? . . . . . _____
7. Describe its consistency (thick or watery liquid). . . . . _____
8. Describe the color of the liquid sulfur in A-3b. . . . . _____
9. What is its consistency? . . . _____
10. From our study we find that allotropes have similar -?-. . . . _____
11. But, that allotropes have different -?- properties. . . . . _____
12. Isotropes have different -?- . . _____
13. Write an equation for the reaction in B-2. . . . . _____ + _____ → _____
14. What happened in B-3? . . . _____
15. Write an equation for this reaction. . . . . _____ + _____ → _____
16. What happened in B-4? . . . _____
17. Write an equation for this reaction. . . . . _____ + _____ → _____
18. What happened in B-5? . . . _____
19. Write an equation for this reaction. . . . . _____ + _____ → _____
20. Complete: Sulfur + Metal → _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 28

HYDROGEN SULFIDE

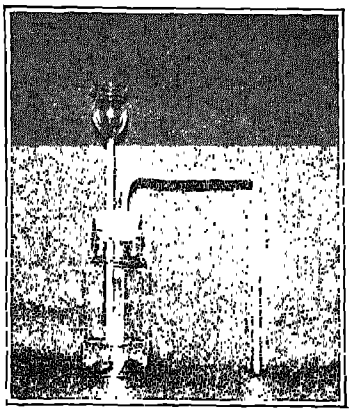
MATERIALS: Ferrous sulfide; hydrochloric acid; solution of antimony chloride, bismuth nitrate, cadmium nitrate, cupric sulfate, lead acetate, lead nitrate, silver nitrate, sodium chloride, zinc nitrate.

APPARATUS: 2 wide-mouth bottles, and 1 2-hole rubber stopper to fit; delivery tube; thistle tube; 10 test tubes; test-tube rack; litmus paper.

Hydrogen sulfide, H_2S, is an important reagent in chemical analysis. It is used in separating metals from their salts, as will be shown in this experiment. It is inflammable and very poisonous, but we are warned of its presence by the odor of rotten eggs. Hydrosulfuric acid, H_2S, is a water solution of hydrogen sulfide. Prepare this gas under a hood, or be sure that the laboratory is well ventilated.

A. PREPARATION.

1. Arrange 8 test tubes in the rack, and pour 10 ml. of distilled water in each tube. Now pour 3 ml. each of
   lead nitrate into the first tube,
   silver nitrate into the second tube,
   cupric sulfate into the third tube,
   sodium chloride into the fourth tube,
   bismuth nitrate into the fifth tube,
   cadmium nitrate into the sixth tube,
   zinc nitrate into the seventh tube, and
   antimony chloride into the eighth tube.
   Save these solutions for B-7.



2. Drop 3 small lumps of ferrous sulfide into a wide-mouth bottle, and assemble the apparatus as shown in the diagram.
3. Pour 15 ml. of water through the thistle tube. Now add hydrochloric acid, in small amounts, to maintain a steady flow of gas.
4. Collect 2 test tubes of hydrogen sulfide by the upward displacement of air. You can tell when the tubes are full by the odor of the escaping gas, or by the lead acetate test as described in B-1. Stopper the tubes and place them in the rack for later use.

B. EXPERIMENTATION.

1. TEST FOR HYDROGEN SULFIDE. Moisten a strip of filter paper with lead acetate solution. Hold this paper in the gas at the mouth of the delivery tube. This test might well be used in A-4.
2. Pour 5 ml. of water into a test tube of hydrogen sulfide. Stopper and shake the tube vigorously. Invert the tube in a beaker of water and remove the stopper.
3. Bring a burning splint to the mouth of a tube of the gas. This is combustion in a limited supply of air, or incomplete combustion. Try to identify the residue deposited on the inside of the tube.
4. Place a glass jet in the end of the delivery tube. Be sure that the gas is flowing steadily. Ignite the gas and test the odor of the product formed. This is combustion in an adequate supply of air, or complete combustion.
5. Test the solution of hydrogen sulfide, in the wide-mouth bottle, with litmus paper.
6. Place a drop of this solution of hydrogen sulfide on a warm silver coin (dime). Observe the results.
7. Place the delivery tube, for a few seconds, into each of the 8 salt solutions in the test-tube rack. Rinse the delivery tube after each test. H_2S is used in this way to identify certain metals (metallic ions) whose sulfides are insoluble and have characteristic colors. Fill in the following table.

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C. OBSERVATIONS.

	HYDROGEN SULFIDE TEST				COLOR
1.	Pb	+ →	+	Pb	
2.	Ag	+ →	+	Ag	
3.	Cu	+ →	+	Cu	
4.	Na	+ →	+	Na	
5.	Bi	+ →	+	Bi	
6.	Cd	+ →	+	Cd	
7.	Zn	+ →	+	Zn	
8.	Sb	+ →	+	Sb	

9. What happened in B-1? . . . _____

10. What did B-2 prove? . . . . _____

11. What happened in B-3? . . _____

12. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

13. Describe the odor, and the color of the flame in B-4. . . . . _____

14. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

15. What did the results of B-5 prove? . . . . . _____

16. What is the name of this compound? . . . . . _____

17. What happened in B-6? . . . _____

18. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

19. What compound is formed when silver tarnishes? . . . . . _____

20. What class of compounds produced the identifying colors in B-7? . . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 29

SULFUR DIOXIDE

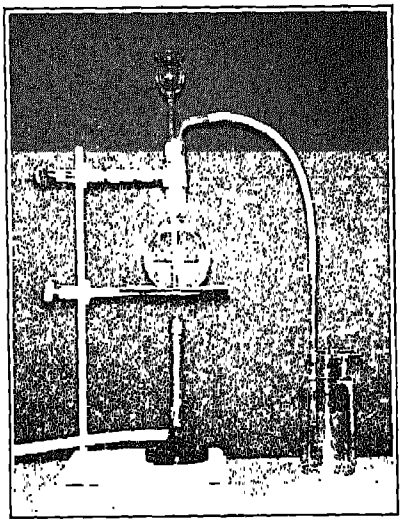
MATERIALS: Sodium sulfite, or sodium bisulfite; sulfuric acid; solutions of barium chloride, potassium permanganate.

APPARATUS: Flask, 2-hole rubber stopper to fit; thistle tube; delivery tube; wire gauze; burner; 3 wide-mouth bottles; 3 glass cover plates; 3 test tubes, 2 solid rubber stoppers to fit; test-tube rack; splints; litmus paper; highly colored flower, or apple peel.

Sulfur dioxide, SO_2, is formed when sulfur burns, by heating sulfides in air (roasting), as a decomposition product of sulfuric acid, and by the action of an acid on a sulfite. It is the anhydride of sulfurous acid, H_2SO_3. Sulfur dioxide is injurious to the mucous lining of the nose and throat, so be careful not to breathe any more of it than is necessary. Collect the gas under the hood, or be sure the laboratory is well ventilated.

A. PREPARATION.

1. Pour 10 grams, 2 rounded teaspoons, of sodium sulfite or sodium bisulfite into the flask.
2. Assemble the apparatus. The end of the delivery tube should be about 2 inches above the bottom of the bottle.
3. Pour 15 ml. of water through the thistle tube. Add 5 ml. of sulfuric acid. Warm the flask gently, if necessary, to start the action. Add small quantities of the acid from time to time, to maintain a steady flow of the gas. If the action becomes too violent, add a little cold water.
4. Collect 3 bottles of sulfur dioxide by the upward displacement of air. A moist piece of blue litmus paper, held over the mouth of the bottle, will change color when the bottle is full of gas. Place a cover glass over the mouth of each bottle as soon as it is full.
5. Fill a dry test tube with the gas. Stopper the tube and place it in the rack for later use.
6. Let the gas bubble through half a test tube of water for about 5 minutes. Stopper the tube and place it in the rack.



B. EXPERIMENTATION.

1. Observe the color and odor of sulfur dioxide.
2. Pour 5 ml. of water into a test tube of sulfur dioxide. Stopper and shake the tube vigorously. Open the mouth of the tube under water.
3. Thrust a burning splint into a bottle of sulfur dioxide.
4. Test the reaction of the sulfur dioxide solution, from A-6, with litmus paper.
5. Gently heat 5 ml. of this solution and cautiously test the odor at the mouth of the tube.
6. Pour 5 ml. of the sulfur dioxide solution into a test tube. Add potassium permanganate solution, drop by drop, until the solution becomes slightly pink. Now add a few drops of barium chloride. A white precipitate indicates the presence of the sulfate ion. (Potassium permanganate is a powerful oxidizing agent.)
7. Place a few petals of a highly colored flower, or a piece of red apple peel, into a bottle of sulfur dioxide. Observe after a few minutes.
8. Repeat B-7, using moist materials.

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C. OBSERVATIONS.

1. Describe the color and odor of sulfur dioxide. . . . . _____

2. Which property of sulfur dioxide is shown in B-2? . . . . . _____

3. Which property of sulfur dioxide is shown in B-3? . . . . . _____

4. What happened in B-4? . . . _____

5. This proves that sulfur dioxide is an -?-. . . . . _____

6. Write an equation for the reaction in A-6. . . . . _____ + _____ → _____

7. What happened in B-5? . . . _____

8. This shows that -?- is unstable. _____

9. Write an equation for this decomposition reaction. . . . . _____ → _____ + _____

10. Write a double replacement equation for the reaction which took place in the generator. _____ + _____ → _____ + _____

11. Write an equation for the decomposition reaction which took place in the generator. . . . . _____ → _____ + _____

12. Write the combined equation for this reaction. . . . . _____ + _____ → _____ + _____ + _____

13. What happened in B-6? . . . _____

14. Write an equation for this reaction. . . . . _____ + (O) → _____

15. What was oxidized? . . . . _____

16. What was reduced? . . . . _____

17. What happened in B-7? . . . _____

18. What happened in B-8? . . . _____

19. What do B-7 & B-8 prove? . _____

20. In this experiment, we prepared sulfur dioxide by the action of -a- on a -b-. . . . . a. _____ b. _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 30

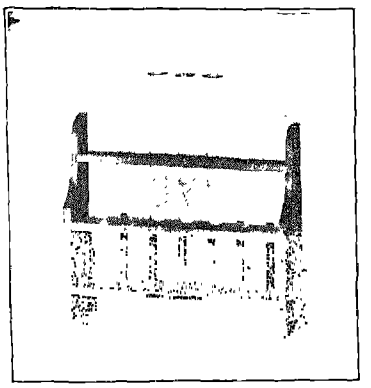
SULFURIC ACID

MATERIALS: Sulfuric acid; hydrochloric acid; copper shot or turnings; zinc; sugar; calcium carbonate; sodium chloride; sodium nitrate; barium chloride solution.

APPARATUS: Beaker; 5 test tubes; test-tube holder; test-tube rack; glass stirring rod; litmus paper; writing paper; burner; splints.

Sulfuric acid, H_2SO_4, was formerly called "oil of vitriol." Today it is referred to as the "king of chemicals." It is our most important acid, in fact it is used more extensively in industry than any other chemical reagent. In this experiment we will study some of its properties. Because it has such a high boiling point (338° C.), sulfuric acid is used to prepare the other common laboratory acids from their salts.

A. DILUTE ACID.



1. Prepare 35 ml. of dilute sulfuric acid (1 : 6). To do this, slowly pour 5 ml. of concentrated sulfuric acid into 30 ml. of water in a beaker. Touch the outside of the beaker below the level of the liquid.
2. Test this dilute acid solution with litmus paper.
3. Arrange 3 test tubes in the rack, and pour 5 ml. of H_2SO_4 (1 : 6) into each of the tubes.
   a. Drop a small piece of zinc into the first tube.
   b. Drop a few copper shot, or turnings, into the second tube.
   c. Drop a small piece of calcium carbonate into the third tube.
   d. Thrust a burning splint into the mouth of each tube. Try to identify the gases evolved. Record results in the table.

B. CONCENTRATED ACID.

1. AN OXIDIZING AGENT.
   a. Place 2 test tubes in the rack, and pour 3 ml. of sulfuric acid into each tube.
   b. Drop a small piece of zinc into the first tube.
   c. Drop a few copper shot, or turnings, into the second tube. Gently warm each tube, to start the action.
   d. Cautiously test the odor at the mouth of each tube.
   (When heated in the presence of an oxidizable substance, sulfuric acid decomposes into water, sulfur dioxide and nascent oxygen: $H_2SO_4 \rightarrow H_2O + SO_2 + (O)$.

2. A DEHYDRATING AGENT.
   a. Pour 2 ml. of sulfuric acid into a test tube, then drop a wood splint into the tube. After about a minute, remove the splint and examine it. (Wood is chiefly cellulose, $C_6H_{10}O_5$.)
   b. Pour a level teaspoon of sugar, $C_{12}H_{22}O_{11}$, into a test tube. Add 2 ml. of sulfuric acid. Observe the results.
   c. Dip a clean stirring rod into some sulfuric acid (1 : 12), (2 ml. of water + 2 ml. of the acid from A-1), and print your initials on a piece of writing paper. Let the paper dry, then warm it over a flame. (Paper is chiefly cellulose.)

3. TO PREPARE OTHER ACIDS.
   a. Place 2 test tubes in the rack, and pour 2 ml. of sulfuric acid into each tube.
   b. Pour ½ level teaspoon of sodium chloride into the first tube, and
   c. Pour ½ level teaspoon of sodium nitrate into the second tube.
   d. Gently warm each tube and test the reaction of the escaping gas with moist litmus paper.

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C. TEST FOR A SULFATE.

1. Pour a few drops of sulfuric acid (1 : 6), or a solution of any sulfate, into a test tube containing 10 ml. of water.
2. Add a few drops of barium chloride solution. Note the results.
3. Add a few drops of hydrochloric acid. Note the results.

D. OBSERVATIONS.

	GAS FORMED	EQUATION
A-3a.		$Zn + H_2SO_4 \rightarrow \quad +$
b.		$Cu + H_2SO_4 \rightarrow \quad +$
c.		$CaCO_3 + H_2SO_4 \rightarrow \quad + \quad +$
B-1b.		$Zn + H_2SO_4 \rightarrow \quad + \quad +$
c.		$Cu + H_2SO_4 \rightarrow \quad + \quad +$
2a.		$C_6H_{10}O_5 \xrightarrow{H_2SO_4} \quad +$
b.		$C_{12}H_{22}O_{11} \xrightarrow{H_2SO_4} \quad +$
B-3b.		$NaCl + H_2SO_4 \rightarrow \quad +$
c.		$NaNO_3 + H_2SO_4 \rightarrow \quad +$
C-2.		$BaCl_2 + H_2SO_4 \rightarrow \quad +$

1. What happened in A-1? . . . _____
2. Write an equation for the ionization of sulfuric acid. . . . . _____ $\rightarrow \quad +$
3. Why does zinc react with dilute sulfuric acid? . . . . . _____
4. Why is it that copper does not react with dilute sulfuric acid? . _____
5. Why is it that zinc and cold conc. sulfuric acid do not react? . . _____
6. Why is there a reaction between zinc and hot conc. sulfuric acid? _____
7. What happened in B-2c? . . _____
8. The color of the letters in B-2c was due to -?-. . . . . _____
9. Why is sulfuric acid used in preparing other acids? . . . . . _____
10. When barium chloride is added to a sulfate, a -a- is formed, which is -b- in hydrochloric acid. . . a. _____ b. _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 31

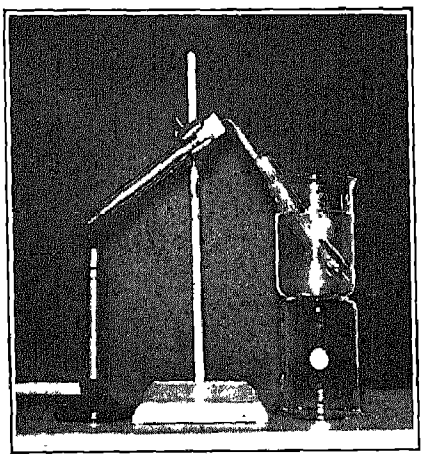
BROMINE: ITS PREPARATION AND PROPERTIES

MATERIALS: Potassium bromide; manganese dioxide; sulfuric acid; chlorine water, freshly prepared; carbon tetrachloride; magnesium ribbon; distilled water.

APPARATUS: 5 test tubes; test-tube rack; test-tube clamp; 1-hole rubber stopper, No. 2; delivery tube; ring-stand; beaker; red cotton cloth.

Bromine vapors are very poisonous, so be very careful not to breathe them. Alcohol vapors counteract its effect to some extent. The liquid produces severe skin burns. In case of an accident, wash the burn with cold water then apply sodium thiosulfate, "hypo," solution. Prepare bromine under a hood, or be sure the laboratory is well ventilated.

A. PREPARATION.



1. Mix 1 gram of potassium bromide and 2 grams of manganese dioxide, ½ level teaspoon of each, on a piece of paper. Pour this mixture into the test-tube generator.
2. Assemble the apparatus. The collecting tube, containing 15 ml. of water, should be immersed in a beaker of cold water.
3. Remove the stopper and add 3 ml. of sulfuric acid (2 : 1).
4. Gently warm the generator. Frothing indicates too high a temperature.
5. When bromide vapors cease to be evolved, remove the delivery tube from the collecting tube, then extinguish the flame under the generator.
6. Disconnect the apparatus, as soon as it is cool, and wash each part thoroughly.

B. EXPERIMENTATION.

1. Pour 1 ml. of carbon tetrachloride into a test tube containing 5 ml. of water.
   a. Stopper and shake the tube, then place it in the rack. Observe whether the two liquids are miscible. Observe their relative densities.
   b. Pour a few drops of bromine water, the water above the liquid bromine in the collecting tube, into the tube. Stopper and shake the tube. Observe the relative solubility of bromine in water and in carbon tetrachloride. (Other organic solvents act in a similar manner: Carbon disulfide, chloroform, ether, etc.)
2. Drop a 0.2 cm. length of magnesium ribbon into a test tube containing 3 ml. of bromine water. Observe whether there is any evidence of a chemical change.
3. Immerse a small piece of red cloth in 5 ml. of bromine water in a test tube. After a few minutes, remove and wash the cloth. Observe the results. The bleaching action of bromine is similar to that of chlorine. Recall or review the bleaching action of chlorine:

$$Cl_2 + H_2O \rightarrow HClO + _____$$
$$HClO \rightarrow _____ + (O)$$

4. TEST FOR BROMINE.
   a. Drop 2 or 3 crystals of potassium bromide, or any soluble bromide, into a test tube containing 5 ml. of distilled water. Stopper and shake the tube until the salt has dissolved.
   b. Add 1 ml. of carbon tetrachloride.
   c. Add a few drops of freshly prepared chlorine water. Observe the change which takes place as the chlorine water becomes mixed with the bromine solution.
   d. Stopper and shake the tube. Observe the change which has taken place in the carbon tetrachloride layer.
5. Pour the unused bromine water into the receptacle on the front desk.

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C. OBSERVATIONS.

Complete and balance the step equations, then the combined equation for the preparation of bromine:

1. $KBr + H_2SO_4 \rightarrow \quad +$
2. $MnO_2 + H_2SO_4 \rightarrow \quad + \quad + (O)$
3. $HBr + (O) \rightarrow \quad +$
4. $KBr + MnO_2 + H_2SO_4 \rightarrow \quad + \quad + \quad +$

5. What gas would have been given off if MnO_2 had not been used? _____
6. What was the function of MnO_2 in this experiment? . . . . . _____
7. What is the color of bromine vapors? . . . . . _____
8. What is the normal color and state of bromine? . . . . . _____
9. How does the density of bromine compare with that of water? . . _____
10. Give the results of B-1a. . . _____
11. Give the results of B-1b. . . _____
12. What happened in B-2? . . . _____
13. Write an equation for this reaction. . . . . _____ $\rightarrow$ _____
14. This shows that bromine combines with -a- to form -b-. . . a. _____ b. _____
15. What happened in B-3? . . . _____
16. Complete the combined equation for this reaction. . . . . $Br_2 + H_2O \rightarrow \quad +$ _____
17. Bleaching with chlorine or bromine is really -?- . . . . . _____
18. What happened in B-4d? . . . _____
19. Write an equation for this replacement reaction. . . . . _____ $+ \rightarrow \quad +$ _____
20. Is this a test for free bromine (Br) or combined bromine (bromine ions, Br^{-1})? . . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 32

IODINE: ITS PREPARATION AND PROPERTIES

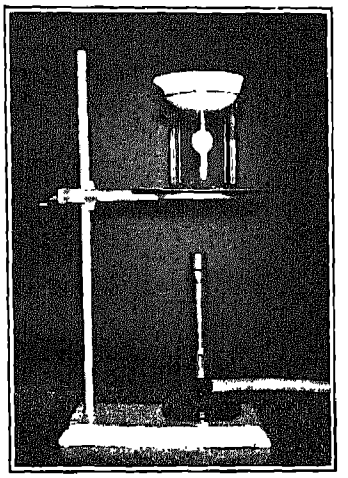
MATERIALS: Potassium iodide; manganese dioxide; sulfuric acid; potassium iodide, 5% solution; carbon tetrachloride; alcohol; chlorine water; bromine water; starch suspension (1 gram in 200 ml. of hot water); powdered antimony.

APPARATUS: Beaker, 250 ml.; evaporating dish; graduate; 4 test tubes; test-tube rack; wire gauze; burner.

Iodine is prepared by the same general method as that used for preparing chlorine and bromine. Its chemical properties are similar to those of the other halogens, except that it is less active and is not as dangerous to use. Iodine produces brown stains on the skin, which may be removed with ammonium hydroxide.

A. PREPARATION.

1. Mix about 1 gram of potassium iodide and 2 grams of manganese dioxide, ½ level teaspoon of each, on a piece of paper. Pour this mixture into a small beaker.
2. Assemble the apparatus as shown in the picture. The evaporating dish should be about 2/3 full of cold water.
3. Pour 9 ml. of sulfuric acid (2 : 1) on the mixture in the beaker and quickly replace the evaporating dish.
4. Gently heat the beaker to vaporize the iodine. Iodine vapors will condense (sublime) on the bottom of the evaporating dish.



B. EXPERIMENTATION.

1. Scrape a crystal of iodine into a test tube. Observe the change in state of the iodine as you gently heat the tube. This is called sublimation.
2. Arrange 4 test tubes in the rack. Drop a crystal of iodine into each of the tubes.
   Pour 3 ml. of water into the first tube (save this for C-1),
   3 ml. of carbon tetrachloride into the second tube,
   3 ml. of alcohol into the third tube, and
   3 ml. of potassium iodide solution in the fourth tube.
   Observe in each case whether iodine is "very soluble," "moderately soluble," "slightly soluble" or "insoluble" in the solvents. Note the color of the solutions. Record results in the table.
3. Place 2 test tubes in the rack. Pour 5 ml. of potassium iodide solution and 1 ml. of carbon tetrachloride into each tube.
   a. Stopper and shake both tubes thoroughly. Note whether the solvent is colored by the potassium iodide, in either tube.
   b. Pour a few drops of chlorine water into the first tube. Stopper and shake the tube. Observe the color change in the carbon tetrachloride.
   c. Pour a few drops of bromine water into the second tube. Stopper and shake the tube. Observe the color change in the carbon tetrachloride.
4. Heat a few crystals of iodine in a small beaker until the iodine vaporizes. Sprinkle some powdered antimony into the beaker.

C. IODINE TESTS.

1. DISPLACEMENT TEST.

   Pour 2 ml. of potassium iodide solution, or any soluble iodide, into a test tube containing 1 ml. of carbon tetrachloride. Add a few drops of chlorine water; stopper and shake the tube. Observe the color change in the carbon tetrachloride.

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2. STARCH — IODINE TEST.
Pour 5 ml. of starch suspension into a test tube. Add 1 drop of a water solution of iodine, from B-2. Observe the color change. This is a delicate test for either starch or iodine.

D. OBSERVATIONS.

	Solute	Solvent	Degree of solubility	Color
1.	Iodine	Water		
2.	Iodine	Carbon tetrachloride		
3.	Iodine	Alcohol		
4.	Iodine	Potassium iodide solution		

5. What is the color of iodine vapor? _____

6. What is the color and state of iodine? . . . . . _____

7. What happened in B-1? . . . _____

8. What is sublimation? . . . . _____

9. What happened in B-3a? . . . _____

10. What happened in B-3b? . . . _____

11. Write an equation for this single replacement reaction. . . . . _____ + _____ → _____ + _____

12. What happened in B-3c? . . . _____

13. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

14. What happened in B-4? . . . _____

15. Write an equation for this reaction. . . . . _____ + _____ → _____

16. Iodine combines with -a- to form -b- (class of salts). . . . . a. _____ b. _____

17. What happened in C-1? . . . _____

18. This is a test for -?- (free or combined) iodine. Why? . . . _____

19. What happened in C-2? . . . _____

20. Complete and balance:

$KI + MnO_2 + H_2SO_4 \rightarrow ____ + ____ + ____$

DATE..... PERIOD..... NAME.....

EXPERIMENT 33

HYDROGEN FLUORIDE — THE HALOGEN TESTS

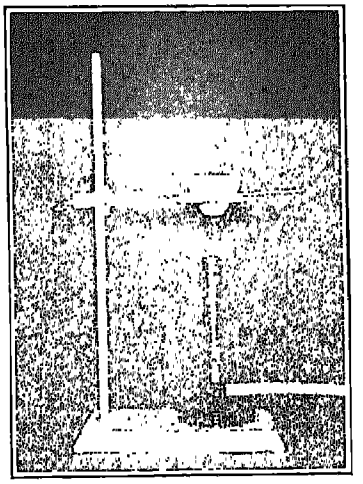
MATERIALS: Calcium fluoride; sulfuric acid; paraffin; silver nitrate solution; carbon tetrachloride; chlorine water; unknowns.

APPARATUS: Lead dish; ring-stand and ring; glass plate; glass rod; nail or file; litmus paper; tongs; burner.

Hydrogen fluoride is a very poisonous gas, and the acid is very corrosive to the skin. Even though hydrofluoric acid is a comparatively weak acid, it possesses the remarkable ability to dissolve (etch) glass. It does this by reacting with glass, and other silicates, forming silicon tetrafluoride, SiF_4, which is a gas. Hydrofluoric acid does not react with wax, lead or platinum.

A. EXPERIMENTATION.

1. Completely cover one side of a glass plate with a thin film of melted paraffin, using a small brush.
2. Use a pin, nail, file, or some other sharp object to scratch your name and date through the paraffin.
3. Pour about 2 grams, ½ level teaspoon, of calcium fluoride into a lead dish. Using a glass rod, stir just enough sulfuric acid into the fluoride to make a fairly thin paste.
4. Assemble the ring-stand and ring under the hood. Place the lead dish on the ring and warm it very gently with a flame.
5. Place moist pieces of litmus paper on the end of a clean glass rod and hold them over the dish. Observe the color change.
6. Extinguish the flame, and place the glass plate over the dish with the paraffin side down. Let the action continue for at least half an hour.
7. Remove the glass plate, using tongs, and immerse it in a beaker of hot water to melt off the paraffin; then dry it with a towel.
8. Use the tongs to transfer the lead dish to the sink. Rinse the dish freely with running water. Be careful to prevent spattering.



B. HALOGEN TESTS.

1. Dissolve a few crystals of the unknown in 10 ml. of distilled water. Divide this solution into two parts, "A" and "B."
2. Add a few drops of nitric acid to "A" and then add a drop or two of silver nitrate solution. A white precipitate indicates the presence of either chlorine, bromine, or iodine ions.
3. If a precipitate is formed in "A," add 1 ml. of carbon tetrachloride to "B," and then a few drops of chlorine water. Stopper and shake the tube. The halogens may be distinguished by the color which they impart to the carbon tetrachloride.

Chlorine	No color change
Bromine	Brownish-red color
Iodine	Violet color

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PROCEDURE	Unknown No. 1	Unknown No. 2	Unknown No. 3
Results of B-2:			
Results of B-3:			
Identity of the unknown:			

C. OBSERVATIONS.

1. General method: Acids are prepared by the action of -?- on a suitable salt. . . . . _____
2. Name the chemicals used in the preparation of hydrogen fluoride. _____
3. What happened in A-5? . . . _____
4. What did this prove? . . . . _____
5. Write an equation for the preparation of hydrogen fluoride. . . _____ + _____ → _____ + _____
6. What is the name of this type of equation? . . . . . _____
7. How would you proceed to prepare hydrofluoric acid? . . . _____
8. What kind of bottles are used for storing hydrofluoric acid? . . _____
9. What happened in A-7? . . . _____
10. What is etched glass? . . . . _____
11. What silicon compound is formed when hydrofluoric acid reacts with glass or other silicates? . . . . . _____
12. Complete and balance: . . . $HF + SiO_2 \rightarrow$ _____ + _____
13. What happens when $AgNO_3$ is added to a chloride solution? . _____
14. Write an equation for this reaction. . . . . $AgNO_3 + M{\bullet}Cl \rightarrow$ _____ + _____
15. What happens when Cl-water is added to a bromide solution? . _____
16. Write an equation for this reaction . . . . . $Cl_2 + M{\bullet}Br \rightarrow$ _____ + _____
17. What is the name of this type of reaction? . . . . . _____
18. What happens when Cl-water is added to an iodide solution? . _____
19. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____
20. List the halogens in the order of their *decreasing* activity. . . . _____, _____, _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 34

PHOSPHORUS — TEST FOR A PHOSPHATE

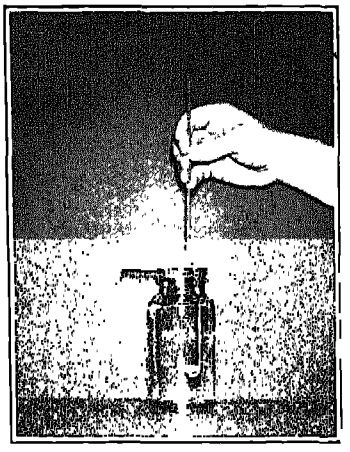
MATERIALS: Yellow phosphorus; nitric acid; ammonium hydroxide; sodium hydroxide; ammonium molybdate solution.

APPARATUS: Deflagrating spoon; wide-mouth bottle; glass plate; ring-stand and ring; test-tube rack; 4 test tubes; beaker, 150 ml.; wire gauze; litmus paper.

Yellow phosphorus is so active that it has to be kept under water to prevent it from combining with the oxygen of the air. If left exposed for a few minutes, it will suddenly burst into flames and burn violently. Be careful in handling this allotrope of phosphorus. It is very poisonous and produces severe burns to both skin and clothing. Do not touch it with your fingers.

A. EXPERIMENTATION.

1. Pour 25 ml. of water into a wide-mouth bottle.
2. Place a small piece of yellow phosphorus, about the size of a grain of rice, into the bowl of a cool, *clean* deflagrating spoon.
3. Ignite the phosphorus by touching it with a warm wire, then quickly lower the spoon into the bottle until the bowl nearly touches the water. Cover the mouth of the bottle with a glass plate.
4. Remove the spoon, as soon as the metal stops burning, and quickly replace the glass plate.
5. Hold the spoon in the flame to burn off any remaining phosphorus. Dip the spoon in water before putting it down.
6. Hold the glass plate firmly in place, and shake the bottle.
7. Pour this liquid into a small beaker, and test its reaction with litmus paper.
8. Add 2 ml. of nitric acid, and gently boil the solution for about 5 minutes. The nitric acid oxidizes any phosphor*ous* compounds which may be present to phosphor*ic* acid.



9. Pour 5 ml. of this acid solution into a small beaker and neutralize it with sodium hydroxide. To do this, drop a small piece of litmus paper (or 2 drops of phenolphthalein) into the beaker, then add the base, drop by drop with constant stirring, until the last drop causes the indicator to change color.

   By adding varying amounts of sodium hydroxide, either of the following phosphates may be formed :

   NaH_2PO_4, monosodium acid phosphate (primary sodium phosphate),
   Na_2HPO_4, disodium acid phosphate (secondary sodium phosphate), or
   Na_3PO_4, normal sodium phosphate (tertiary sodium phosphate).

B. TEST FOR A PHOSPHATE.

1. Pour a few drops of the phosphoric acid solution, or any soluble phosphate, into a test tube containing 5 ml. of ammonium molybdate solution.
2. Gently warm the tube, and note the results. Divide the product into two parts, A and B.
   a. Add a few drops of ammonium hydroxide to "A." Shake the tube and observe the results.
   b. Add a few drops of nitric acid to "B." Shake the tube and observe the results.

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C. OBSERVATIONS.

1. Which allotrope of phosphorus was used in this experiment? . _____

2. What is the appearance of phosphorus pentoxide, P_2O_5 (the product formed in A-3)? . . . . . _____

3. Write an equation for this reaction. . . . . _____ + _____ → _____

4. What happened in A-6? . . _____

5. What happened in A-7? . . . _____

6. Give the name and formula for this compound. . . . . _____

7. Write an equation for this reaction. . . . . _____ + _____ → _____

8. What name is applied to an oxide which will combine with water in this manner?. . . . . _____

9, 10, 11. Write equations to show that either of the three sodium salts of phosphoric acid might have been formed in A-9, by using different amounts of the base. .

_____ + _____ → NaH_2PO_4 + _____

_____ + _____ → Na_2HPO_4 + _____

_____ + _____ → Na_3PO_4 + _____

12. Since the acid was completely neutralized which of these salts was really formed? . . . . _____

13. What name is applied to an acid which can produce three classes of salts? . . . . . _____

14. Give the name of the class of salts formed by partially neutralizing such an acid. . . . . _____

15. Salts resulting from the complete neutralization of an acid are called -?-. . . . . _____

16. What happened in B-2? . . . _____

17. What happened in B-2a? . . _____

18. What happened in B-2b? . . . _____

19, 20. Phosphate Test: Warm a few drops of the unknown with a solution of -a-. If phosphate ions are present, a -b- precipitate will be formed, which is soluble in -c-, but insoluble in -d-. . . . a. _____ b. _____

c. _____ d. _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 35

CARBON

MATERIALS: Animal charcoal; wood charcoal, powdered; cupric oxide; lead oxide, PbO; limewater; ammonium hydroxide (or ammonium sulfide solution); potassium permanganate, 0.02% solution (or vinegar).

APPARATUS: 4 test tubes, Pyrex or hard glass; test-tube clamp; test-tube holder; ring-stand and ring; funnel; filter paper; beaker; charcoal block; burner; blowpipe; asbestos mat.

Carbon occurs abundantly in nature in compounds and in a number of radically different uncombined forms. Coal, coke, charcoal, boneblack, lampblack, graphite, and diamond differ so greatly that it is hard to realize that they are allotropic forms of the same element. They are alike, though, in that they are all odorless, tasteless, insoluble in all ordinary solvents, and form carbon dioxide when burned in air.

A. EXPERIMENTATION.

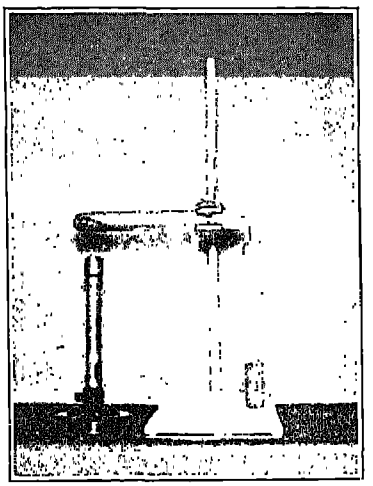
1-a. Pour a rounded teaspoon of animal charcoal (boneblack), through a paper funnel, into a Pyrex, or hard glass, test tube.

b. Dry the charcoal by heating the tube, gently at first and then more intensely, for 3 or 4 minutes. After this, remove the flame and allow the tube to cool.

c. Add 10 ml. of potassium permanganate (0.02%), or vinegar. Stopper and shake the tube vigorously for a minute.

d. Remove the stopper. Boil the mixture gently for 2 or 3 minutes; then filter it.

e. Compare the color of the filtrate with the original solution.



2-a. Pour a rounded teaspoon of powdered wood charcoal into a Pyrex, or hard glass, test tube.

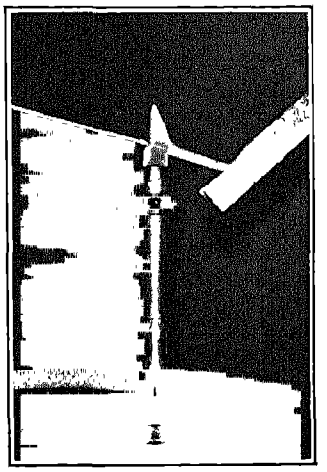
b. Heat the tube for 3 or 4 minutes; then allow it to cool.

c. Add 10 ml. of water and 1 drop of ammonium hydroxide (or an ammonium sulfide solution). Cautiously test the odor of the mixture.

d. Stopper and shake the tube for 2 or 3 minutes.

e. Compare the odor now with that of the original mixture.

3-a. Thoroughly mix 5 grams of cupric oxide, 1/8 level teaspoon, and 1 gram of powdered wood charcoal, 1/2 level teaspoon, on a piece of paper. Pour this mixture into a Pyrex, or hard glass, test tube.



b. Assemble the apparatus. The delivery tube extends into a test tube containing 10 ml. of limewater.

c. Heat the tube gently at first and then more strongly for at least 5 minutes. Observe the change which takes place as the gas bubbles through the limewater.

d. Remove the delivery tube; extinguish the flame; and allow the tube to cool.

e. Pour the contents of the generator into a beaker. Place the beaker in the drain and gently run water into it to overflowing, to wash out the charcoal.

f. Observe the color of the product which remains in the beaker.

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4-a. Make a *small* depression in a charcoal block with a file or some other sharp instrument.
b. Pour a small amount of lead oxide, PbO, into this depression.
c. Heat the compound with the reducing flame of a blowpipe until a metallic globule is formed. Dump this molten metal on an asbestos mat.
d. Examine this new substance.

B. OBSERVATIONS.

1. What happened in A-1e? . . _____
2. Which property of charcoal is shown by this experiment ? . . _____
3. What happened in A-2e? . . _____
4. Which property of charcoal is shown by this experiment? . . _____
5. Is this a physical or a chemical property? . . . . . _____
6. What happened in A-3c? . . _____
7. This is a test for -?-. . . . . _____
8. Write an equation for this reaction, A-3c. . . . . _____ + _____ → _____ + _____
9. Why was the delivery tube removed before the flame was extinguished in A-3d? . . . . _____
10. Give the appearance and suggest a name for the product in A-3f. _____
11. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____
12. What happened to some of the charcoal? . . . . . _____
13. What is the reducing agent? . _____
14. What is reduced? . . . . . _____
15. What is the oxidizing agent? . _____
16. What is oxidized? . . . . . _____
17. Which property of carbon is shown by A-3? . . . . . _____
18. Give the appearance and suggest a name for the product in A-4d. _____
19. What is the reducing agent? . _____
20. Write an equation for this reaction, A-4c. . . . . _____ + _____ → _____ + _____

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EXPERIMENT 36

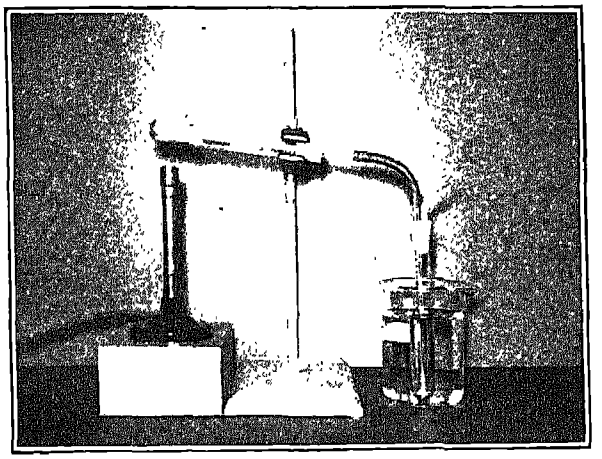
FUELS — DESTRUCTIVE DISTILLATION

MATERIALS: Sodium acetate; soda lime; calcium carbide; wood splints; limewater.

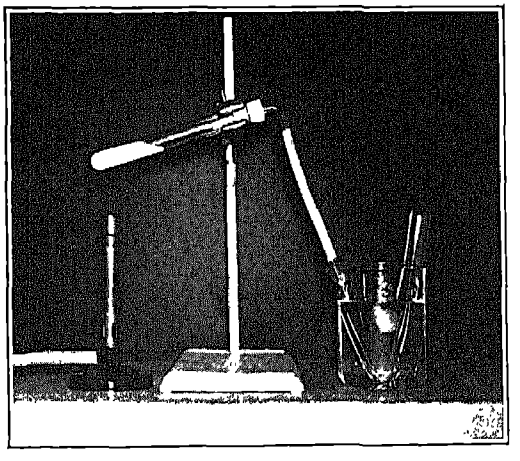
APPARATUS: 5 test tubes; 1 Pyrex or ignition tube; thistle tube; beaker; ring-stand; litmus paper; test-tube clamp; wide-mouth bottle; jet tube.

Destructive distillation is the process by which complex organic substances are broken down into simpler substances by being heated in the absence of air. It is called "destructive distillation" because the products formed during the process cannot be recombined to form the original substance. As performed in industry, it is a very ingenious method for producing coke and charcoal, and at the same time collecting and making use of all of the many valuable by-products which in the normal process of burning, pass off into the air and are wasted.

A. DESTRUCTIVE DISTILLATION.



1. Break 3 wood splints into inch lengths and place them in the ignition tube.
2. Assemble the apparatus. Incline the mouth of the tube slightly downward.
3. Heat the ignition tube gently at first and then very strongly until all of the volatile matter has been driven off.
   a. Test the reaction of the gas with moist litmus paper.
   b. Bring a flame to the gas jet.
   c. Note the color of the liquid in the condensing tube. This is pyroligneous acid, the commercial source of methyl (wood) alcohol, acetic acid, acetone, wood tar, etc.
   d. Test the reaction of this liquid (A-3c).
   e. Test to see whether it will burn.
   f. Examine the product in the ignition tube.



B. METHANE, CH_4.

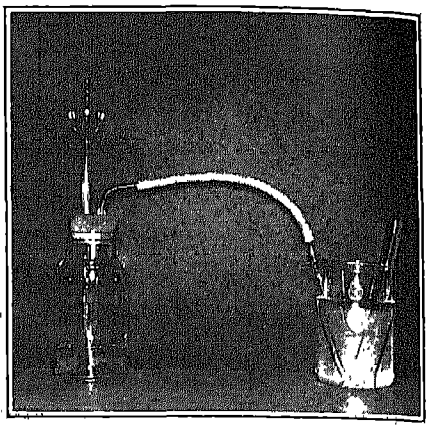
1. Place 2 grams, 1 level teaspoon, of sodium acetate and 4 grams, 1 rounded teaspoon, of soda lime on a piece of paper. Poor this mixture into a test tube.
2. Assemble the apparatus.
3. Gently heat the generator and collect 4 test tubes of methane by the displacement of water.
   a. Observe the color and odor of methane.
   b. Bring a flame to the mouth of each tube as it is filled. Compare the results.
4. Substitute a jet tube for the delivery tube.
   a. Ignite the gas and observe the nature of the flame.
   b. Hold a clean beaker, which is about ½ full of cold water, over the flame for a moment. Observe the results.
   c. Invert a clean, dry wide-mouth bottle over the flame for half a minute. Turn the bottle upright; add 5 ml. of limewater and shake. Interpret the results.

C. ACETYLENE, C_2H_2.

1. Drop 3 or 4 small lumps of calcium carbide into a dry, wide-mouth bottle. Acetylene is poisonous and explosive when mixed with air, so follow directions carefully.

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2. Assemble the apparatus. The thistle tube should barely touch the bottom of the bottle.
3. Pour water, through the thistle tube, drop by drop, and collect 5 test tubes of the gas.
   a. Observe the color and cautiously test the odor of acetylene.
   b. Repeat B-3b, for acetylene.
4. As soon as the last tube of gas burns quietly when brought to a flame, substitute a jet tube for the delivery tube.
   a. Ignite the gas and observe the nature of the flame.
   b. Repeat B-4b, for acetylene.
   c. Repeat B-4c, for acetylene.
5. Test the reaction of the liquid in the generator bottle.



D. OBSERVATIONS.

1. What happened in A-3a? . . . _____
2. What happened in A-3b? . . _____
3. Give the name and color of the liquid in the condensing tube. . _____
4. What effect does this liquid have on litmus paper? . . . . . _____
5. Is this liquid combustible? . . _____
6. Give the appearance and suggest a name for A-3f. . . . . _____
7. Write an equation for the reaction in B-3. . . . . NaOH + _____ → _____ + _____
8. Describe the color and odor of methane. . . . . _____
9. Give the results of B-3b. . . . _____
10. What does B-3b prove? . . . _____
11. Describe the flame which is formed when methane burns. . _____
12. What is proven by the results of B-4b and B-4c? . . . . . _____
13. Write an equation for the combustion of methane. . . . . _____ + _____ → _____ + _____
14. Describe the color and odor of acetylene. . . . . _____
15. What did you prove by the results of C-3b? . . . . . _____
16. Describe the flame which is formed when acetylene burns. . . _____
17. What is proven by the results of C-4b and C-4c? . . . . . _____
18. Write an equation for the combustion of acetylene. . . . . _____ + _____ → _____ + _____
19. What do the results of C-5 prove? _____
20. Write an equation for the preparation of acetylene. . . . . _____ + _____ → _____ + _____

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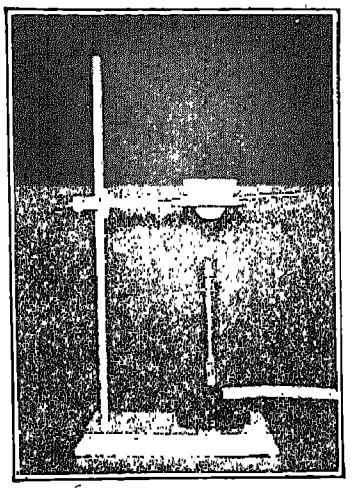
EXPERIMENT 37

METALLURGY

MATERIALS: Lead sulfide (or cupric sulfide); cupric sulfate solution; charcoal block.

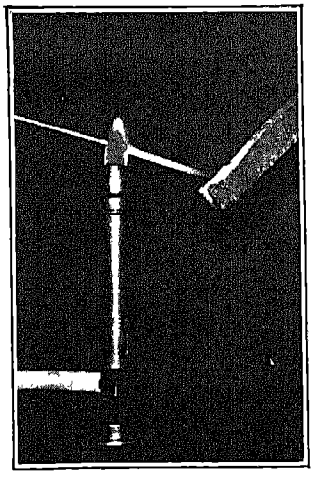
APPARATUS: Porcelain crucible; small beaker; ring-stand and ring; clay triangle; blowpipe; 2 carbon electrodes; 2 dry cells, or other source of direct current electricity; burner.

The earth is the storehouse from which we get all of our metals. A few are found free in nature, but most of them occur as compounds. Any earthy substance which has a fairly uniform composition is called a mineral. Any mineral from which a metal can be profitably extracted is called an ore. The extraction of a metal from its ore is called metallurgy. Metallurgy is usually accomplished by one or more of the following processes: Roasting, reduction, and electrolysis.



A. ROASTING.

1. Pour ¼ teaspoon of lead sulfide into a porcelain crucible.
2. Assemble the apparatus, and heat the crucible strongly for a few minutes.
3. Cautiously test the odor of the escaping gas.
4. Observe the change in appearance of the compound in the crucible. It is now the oxide.

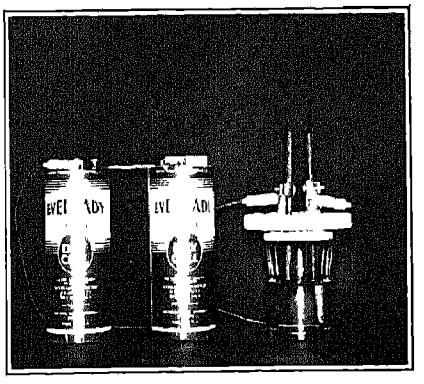


B. REDUCTION.

1. Place some of the lead oxide, from A-4, in the depression in a charcoal block.
2. Heat this compound with the reducing flame of a blowpipe until a globule of molten metal has been formed. Carefully pour the molten metal on the base of your ring-stand.
3. Observe the change which has taken place during this process.

C. ELECTROLYSIS.

1. Pour about 30 ml. of cupric sulfate solution into a small beaker.
2. Connect a carbon rod to each of the two terminals of a battery, consisting of 2 dry cells connected in series, or a direct current outlet.
3. Dip the carbon electrodes into the beaker and permit the current to flow through the solution for a few minutes. Do not let the electrodes touch each other.
4. Disconnect the apparatus and examine the electrodes.



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D. OBSERVATIONS.

1. Describe the odor of the gas formed in A-3. . . . . _____
2. Suggest a name for this gas. . . _____
3. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____
4. Suggest another name for "roasting." . . . . . _____
5. Write an equation for the roasting of zinc carbonate. . . . . _____ → _____ + _____
6. Write an equation for the roasting of limonite. . . . . _____ $Fe_2O_3 \cdot 3H_2O$ → _____ + _____
7. Roasting is the process by which sulfide, carbonate, and hydrated oxide ores are converted into -?-. _____
8. What change did you observe in B-3? . . . . . _____
9. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____
10. What is reduced? . . . . . _____
11. What is the reducing agent? . . _____
12. Reduction is the process by which metals are obtained by heating -a- ores with -b-. . . . a. _____ b. _____
13. What did you observe in C-3 to indicate that a chemical change was taking place? . . . . . _____
14. Write an equation to show the change which takes place when $CuSO_4$ dissolves in water. . . _____ → _____ + _____
15. Write an equation to show that cupric ions receive 2 electrons (+2e) from the cathode (—) and become copper atoms. . . _____ $\xrightarrow{+2e}$ _____
16. Write an equation to show that sulfate ions give up 2 electrons (—2e) to the anode (+) and become sulfate "atoms." . . _____ $\xrightarrow{-2e}$ _____
17. Show how sulfate atoms combine with the hydrogen of water. . _____ + _____ → _____ + _____
18. What change takes place at the cathode (—)? . . . . . _____
19. What change takes place at the anode (+)? . . . . . _____
20. Write the combined equation for the electrolysis of a cupric sulfate solution. . . _____ + _____ → _____ + _____

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EXPERIMENT 38-A

FLAME TESTS

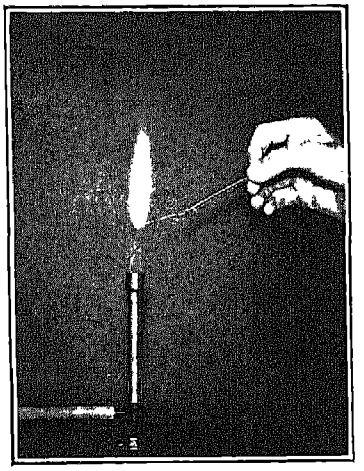
MATERIALS: Salts of barium, calcium, copper, lithium, strontium, sodium, potassium; unknowns.

APPARATUS: Platinum (or nichrome) wire, fused in the end of a glass tube; 3 test tubes; test-tube rack; cobalt glass; burner; emery cloth.

Many of the more active metals vaporize readily and produce characteristic colors when their salts are heated in a flame. These colors are used in the laboratory as one means of identifying metallic ions. To obtain reliable results, the compounds must be pure and all of the apparatus must be kept scrupulously clean.

A. EXPERIMENTATION.

1. Adjust the burner so as to produce a nonluminous, blue flame.
2. Clean a platinum wire by dipping it into hydrochloric acid, 3 ml. in a test tube, and heating it in a flame. (Clean nichrome wire by polishing it with emery cloth.)
3. Dip the end of the wire into distilled water, 3 ml. in a test tube, and then touch it to a speck of a barium salt.
4. Hold the end of the wire in the hottest part of a flame. Record the color of the flame.
5. Repeat this procedure for each of the salts listed in the table.
6. When testing a mixture of sodium and potassium salts, drop 2 or 3 crystals of each into a test tube. Add a drop of distilled water, and then test the solution as before.
7. Observe the color of the flame, for the metals indicated, through 2 or 3 thicknesses of cobalt glass, held close to the eyes.



	Metal	Formula	Color of the Flame	Flame color through Cobalt Glass
1.	Barium			* * * * * *
2.	Calcium			* * * * * *
3.	Copper			* * * * * *
4.	Lithium			* * * * * *
5.	Strontium			* * * * * *
6.	Sodium			
7.	Potassium			
8.	Mixture of Na & K			
9.		Unknown No.		
10.		Unknown No.		

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EXPERIMENT 38-B

HYDROLYSIS

MATERIALS: Solution of aluminum sulfate, cupric sulfate, ferric chloride, lead nitrate, sodium acetate, sodium carbonate, sodium chloride, sodium phosphate, sodium sulfide, sodium tetraborate (borax).

APPARATUS: 10 test tubes; test-tube rack; litmus paper; stirring rod.

Hydrolysis is just the reverse of neutralization. Water ionizes slightly, forming hydrogen (H^+) and hydroxyl (OH^-) ions. These react with the ions formed when salts dissolve to produce an acid and a base. The reaction of a water solution of salt is dependent upon which of the two compounds formed, the acid or the base, is the stronger. If a strong (highly ionized) acid and a weak (poorly ionized) base are formed, the solution will give an acid reaction. Conversely, if a weak acid and a strong base are formed, the solution will give a basic reaction because it contains a greater number of hydroxyl ions. Of course, if the acid and the base are ionized to the same extent (are of the same strength) the solution will be neutral.

A. EXPERIMENTATION.

1. Arrange 10 test tubes in the rack.
2. Pour 5 ml. of aluminum sulfate into the first tubes, and an equal volume of the other salt solutions, in the order mentioned in the table below, in the other tubes.
3. Remove a drop of aluminum sulfate with a clean glass rod and test its reaction with litmus paper. Wash the rod and dry it on a towel after each test.
4. Test the reaction of each of the other salt solutions, in a similar manner. Record the results in the table.

	EQUATION	REACTION	IONS IN EXCESS
1.	$Al_2(SO_4)_3 + HOH \rightarrow \quad +$		
2.	$CuSO_4 + \quad \rightarrow \quad +$		
3.	$FeCl_3 + \quad \rightarrow \quad +$		
4.	$NaC_2H_3O_2 + \quad \rightarrow \quad +$		
5.	$Na_2CO_3 + \quad \rightarrow \quad +$		
6.	$NaCl + \quad \rightarrow \quad +$		
7.	$Pb(NO_3)_2 + \quad \rightarrow \quad +$		
8.	$Na_3PO_4 + \quad \rightarrow \quad +$		
9.	$Na_2S + \quad \rightarrow \quad +$		
10.	$Na_2B_4O_7 + \quad \rightarrow \quad +$		

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EXPERIMENT 39

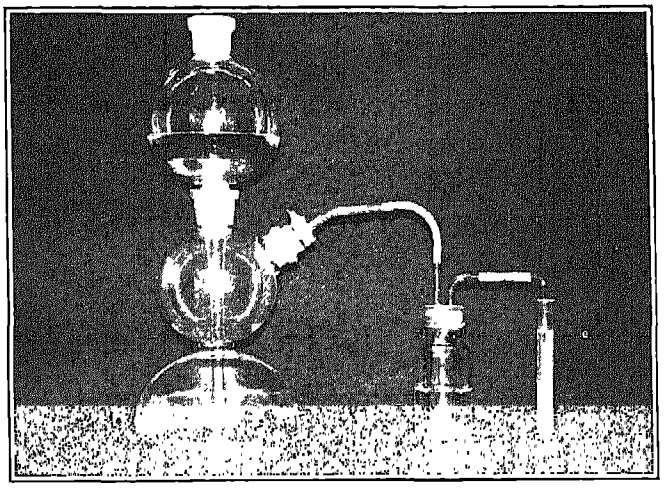
THE SOLVAY PROCESS

MATERIALS: Marble chips; sodium chloride; hydrochloric acid; ammonium hydroxide; lime-water.

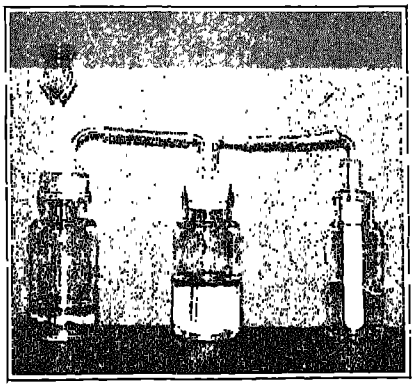
APPARATUS: Kipp generator, or a wide-mouth bottle, 2-hole rubber stopper, and a thistle tube; 1 wide-mouth bottle; 1 2-hole rubber stopper; 3 Pyrex test tubes; flask; beaker; funnel; watch glass; filter paper.

The Solvay Process merits your consideration for two important reasons. First, because the products formed are of such great importance. You will need only to think of the uses of baking soda and washing soda to realize this. And second, because it is an excellent example of the way by-products are utilized in industrial processes. All of the compounds formed during this complicated process, except the desired products and calcium chloride, are used directly as reagents in some other stage of the process. So that, after the process has been once started, the only chemicals which have to be added to keep the reaction in operation are salt (NaCl) and limestone ($CaCO_3$).

A. EXPERIMENTATION.



1. Pour 15 ml. of concentrated ammonium hydroxide into a flask, and add an equal volume of distilled water.
2. Add a level teaspoon of ice cream salt (NaCl). Stopper and shake the flask to dissolve the salt. Repeat this procedure until a saturated solution has been formed.
3. Assemble the gas generator.
   a. If a Kipp generator is used, cover the bottom of the middle globe with glass beads, then cover the glass beads with a half-inch layer of marble chips.
   b. If the second method is used, pour 10 grams, 1 heaping teaspoon, of marble chips into the wide-mouth bottle. Then add enough water to cover the marble chips and seal the end of the thistle tube.



4. Connect the delivery tube to a "wash bottle," which is ½ full of water. This serves to remove any of the acid which might come over with the gas.
5. Filter the salt solution, prepared in A-2, to remove the undissolved salt. Pour the filtrate into a test tube.
6. Pour acid into the generator to start the action.
   a. If a Kipp generator is used, close the valve to the middle globe, and pour hydrochloric acid (1 : 4) into the generator until the top globe is about ¾ full.
   b. If the second method is used, pour conc. HCl, in small amounts, through the thistle tube so as to maintain a slow, steady flow of gas.
7. Carbon dioxide should slowly bubble through the saturated ammoniacal salt solution until a large amount of white precipitate has been formed. This process requires from 60 to 90 minutes, unless a frit tube is used. (Sodium bicarbonate is insoluble in the presence of ammonium salts.)
8. Filter the contents of the reaction tube.
9. Dry the precipitate by pressing it between paper towels or filter paper.

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10. Heat the precipitate on a watch glass, over a water bath (over ¼ of a beaker of gently boiling water), until it no longer smells of ammonia.
    a. Compare the taste of the residue with that of sodium bicarbonate from the reagent bottle.
11. Pour a teaspoon of the dry residue into a clean, dry test tube; and attach a delivery tube. Clamp this generator tube to the ring-stand so the mouth slants slightly downward. Now place the end of the delivery tube into a test tube containing 10 ml. of limewater.
12. Heat the generator, gently at first and then strongly, until the gas ceases to be evolved.
    a. Observe the change in the limewater.
    b. Note the deposit near the mouth of the generator tube.
13. Allow the sodium carbonate to cool. Pour 10 ml. of water into the tube. Heat the tube in a beaker of boiling water, and shake it from time to time. Add more water if necessary, a few drops at a time, until all the salt dissolves.
14. Pour this solution into a beaker. Observe the results as it cools. The product is hydrated sodium carbonate, $Na_2CO_3 \cdot 10H_2O$, or washing soda.

B. OBSERVATIONS.

1. Name the two raw materials used in the Solvay process. . . . . a. _____ b. _____
2. Name the two products of the Solvay process. . . . . a. _____ b. _____
3. Name the one by-product of the Solvay process. . . . . _____
4. How can you tell when the solution is saturated, in A-2? . . _____
5. What are the three substances in the filtrate, in A-5? . . . . . _____ , _____ , _____
6. Write an equation for the generator reaction. . . . . _____ + _____ → _____ + _____ + _____
7. Represent the reaction between CO_2 & H_2O, in the reaction tube. _____ + _____ → _____
8. The reaction between carbonic acid and ammonium hydroxide. _____ + _____ → NH_4HCO_3 + _____
9. The reaction between ammonium bicarbonate and sodium chloride. _____ + _____ → _____ + _____
10. What is the composition of the filtrate, in A-8? . . . . . _____
11. Since $NaHCO_3$ is soluble in water, explain its action in A-7. _____
12. What is the common name for sodium bicarbonate? . . . . _____
13. What happened in A-12a? . . _____
14. What does this prove? . . . . _____
15. What happened in A-12b? . . _____
16. Why was the mouth of the tube slanted downward, in A-11? . . _____
17. Write an equation for the reaction in A-12. . . . . _____ → _____ + _____ + _____
18. What happened in A-14? . . _____
19. Write an equation for this reaction. . . . . _____ + _____ → _____
20. Write the combined equation for the preparation of:

_____ + _____ + _____ → _____ + $NaHCO_3$

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EXPERIMENT 40

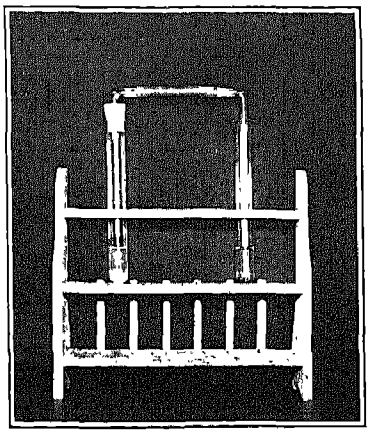
BAKING POWDER

MATERIALS: Sodium bicarbonate; cream of tartar; potassium alum; ammonium alum; monocalcium acid phosphate; disodium acid phosphate; limewater; hydrochloric acid; starch.

APPARATUS: 6 test tubes; test-tube rack; test-tube clamp; ring-stand; delivery tube; beaker; stirring rod.

Baking soda, $NaHCO_3$, is used as the leavening agent when baking with sour milk, which contains lactic acid, $H{\cdot}C_3H_5O_3$. Baking powder is used as the leavening agent when sour milk is omitted from the recipe, because it contains baking soda and in addition some compound which will hydrolize to produce an acid reaction. It also contains either starch or flour, which serves to keep the acid-producing compound dry until it is ready for use.

A. TYPICAL ACTION OF AN ACID ON A CARBONATE.



1. Dissolve 1 gram, ½ level teaspoon, of baking soda in 10 ml. of water, in a test tube.
2. Assemble the apparatus. The end of the delivery tube extends into a test tube containing 10 ml. of limewater.
3. Pour a few drops of hydrochloric acid into the tube containing the baking soda, and quickly replace the stopper.
   a. Observe the change in the limewater.

B. ACID-PRODUCING COMPOUNDS USED IN BAKING POWDER.

1. Arrange 5 test tubes in the rack.
2. Pour about 1 gram, ½ level teaspoon, of
   cream of tartar, $KHC_4H_4O_6$, into the first tube,
   disodium acid phosphate, Na_2HPO_4, into the second,
   monocalcium acid phosphate, $Ca(H_2PO_4)_2$, into the third tube,
   potassium alum, $KAl(SO_4)_2$, into the fourth tube, and
   ammonium alum, $NH_4Al(SO_4)_2$, into the fifth tube.
3. Pour 10 ml. of water into each tube, and heat gently until the compound dissolves.
   a. Test the reaction of each solution.
4. Drop about 0.5 grams, ¼ level teaspoon, of baking soda into each of the tubes, and immediately test the gas with a burning splint.

C. MAKING A CREAM OF TARTAR BAKING POWDER.

1. Pour the following compounds into a clean, dry beaker:
   7 grams, 2½ level teaspoons, of cream of tartar,
   3 grams, 1 level teaspoon, of baking soda, and
   1 gram, ½ level teaspoon, of starch.
   Thoroughly mix these ingredients with a clean, dry stirring rod.

2-a. Pour 1 gram, ½ level teaspoon, of this mixture into a test tube, and assemble the apparatus as in "A."
   b. Gently warm the tube, and observe the results.

3. Take the remainder of this baking powder home and use it to make biscuits.

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D. OBSERVATIONS.

1. What happened in A-3a? . . _____
2. What does this prove? . . . _____
3. What is the typical action of an acid on a carbonate?. . . . _____
4. What happened in B-3a? . . _____
5. What does this prove? . . . _____
6. What happened in B-4? . . _____
7. What happened in C-2b? . . _____
8. Why isn't it necessary to use sour milk with baking powder? . . _____

Complete and balance the following equations for reactions which took place in this experiment:

9. $Na_2HPO_4 + HOH \rightarrow NaOH +$ _____
10. $KHC_4H_4O_6 + HOH \rightarrow \quad +$ _____
11. $Ca(H_2PO_4)_2 + HOH \rightarrow \quad +$ _____
12. $KAl(SO_4)_2 + HOH \rightarrow Al(OH)_3 + \quad +$ _____
13. $NH_4Al(SO_4)_2 + HOH \rightarrow \quad + \quad +$ _____
14. $HCl + NaHCO_3 \rightarrow \quad + \quad +$ _____
15. $H\text{-}C_3H_5O_3 + NaHCO_3 \rightarrow \quad + \quad +$ _____
16. $Na_2HPO_4 + NaHCO_3 \rightarrow \quad + \quad +$ _____
17. $KHC_4H_4O_6 + NaHCO_3 \rightarrow NaKC_4H_4O_6 + \quad +$ _____
18. $Ca(H_2PO_4)_2 + NaHCO_3 \rightarrow CaHPO_4 + Na_2HPO_4 + \quad +$ _____
19. $KAl(SO_4)_2 + NaHCO_3 \rightarrow Al(OH)_3 + K_2SO_4 + Na_2SO_4 +$ _____
20. $NH_4Al(SO_4)_2 + NaHCO_3 \rightarrow \quad + \quad + \quad +$ _____

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EXPERIMENT 41

CALCIUM COMPOUNDS

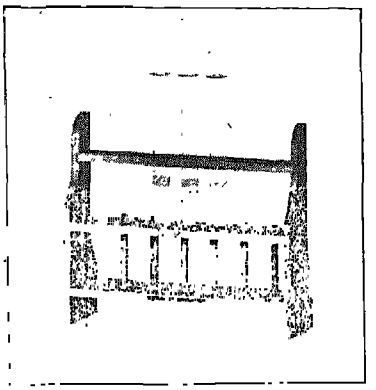
MATERIALS: Marble chips; plaster of paris; old mortar; sulfuric acid; hydrochloric acid; nitric acid; limewater; oil, vaseline, or kerosene.

APPARATUS: 5 test tubes; test-tube rack; delivery tube; burner; litmus paper; ring-stand and ring; wire gauze, 2 pieces; evaporating dish; graduated test tube.

Calcium carbonate is the most abundant and the most useful compound of calcium. It is the source of calcium oxide and calcium hydroxide, which are nearly as important as their parent compound. Gypsum is the second most abundant calcium compound. It is the source of plaster of paris. These five compounds are of the utmost importance in the building industry. In fact, there are comparatively few modern industries which do not make use of one or more of these compounds.

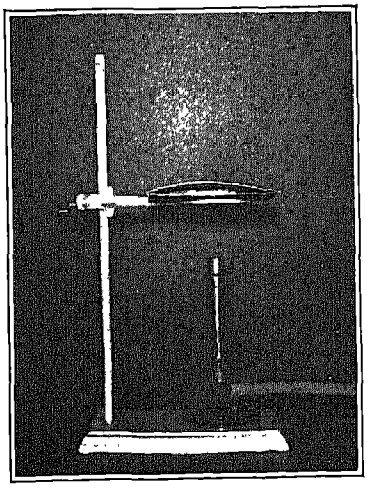
A. CALCIUM CARBONATE, $CaCO_3$ (Limestone, Marble).

1. Arrange 3 test tubes in the rack.
2. Pour 5 ml. of sulfuric acid (1 : 4) into the first tube,
   5 ml. of nitric acid (1 : 4) into the second tube,
   5 ml. of hydrochloric acid into the third tube.
3. Drop a small piece of marble into each tube.
4. Test for carbon dioxide.



B. CALCIUM OXIDE, CaO (Lime, Quicklime).

1. Place 3 or 4 small pieces of marble between 2 pieces of wire gauze. Heat the marble very gently at first, and then in the hottest part of the flame. Proceed with "D" and "E" while the heating continues.
2. After at least 15 minutes, remove the flame and permit the compound to cool.
   a. Observe the appearance and test the hardness of calcium oxide.
   b. Test its solubility in water.
   c. Test the reaction of the solution.



C. CALCIUM HYDROXIDE, $Ca(OH)_2$ (Slaked Lime).

1. Place the remaining lumps of lime, from B-2, in a test tube and add a drop or two of water. This illustrates the slaking of lime.
   a. Feel the bottom of the tube.
   b. Compare the appearance and bulk of the original compound with this product.
2. Add 10 ml. of water, stopper and shake the tube.
   a. Observe the solubility of calcium hydroxide.
   b. Test the reaction of the solution.

D. PLASTER OF PARIS $(CaSO_4)_2 \cdot H_2O$.

1. Place 10 grams, 1 rounded teaspoon, of plaster of paris in an evaporating dish and mix with enough water to make a thick paste. Transfer this paste to a piece of writing paper.
2. Spread a thin film of oil, vaseline or kerosene on a coin or key. Press the article, oily side down, into the plaster of paris.
3. After at least 15 minutes, remove the article and examine the impression. Plaster of paris combines with water to form gypsum, $CaSO_4 \cdot 2H_2O$.

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E. MORTAR.

1. Assemble a test tube gas-generator. Let the end of the delivery tube extend into a test tube containing 10 ml. of limewater.
2. Place a few small pieces of old mortar in the generator tube and add 10 ml. of hydrochloric acid (1 : 4).
   a. Observe the change which takes place in the limewater.
   b. Try to identify the undissolved solid which remains in the generator tube.

F. OBSERVATIONS.

1. What happened in A-4? . . . _____
2. Carbon dioxide is always formed when -?- . . . . . _____
3. Give one method of preparing calcium salts. . . . . _____
4. Write an equation for the reaction in B-1. . . . . _____ → _____ + _____
5. Describe the appearance and hardness of calcium oxide. . . _____
6. Give the results of B-2b. . . . _____
7. Give the results of B-2c. . . . _____
8. What does this indicate about the composition of the solution formed in B-2b? . . . . . _____
9. Give the results of C-1a. . . . _____
10. What does this indicate? . . . _____
11. Write an equation for the slaking of lime. . . . . _____ + _____ → _____
12. Give the results of C-2b. . . . _____
13. Write an equation for the reaction in D-3. . . . . _____ + _____ → _____
14. Plaster of paris casts are really -?- casts. . . . . _____
15. What happened in E-2a? . . . _____
16. What does this prove about the composition of old mortar? . . _____
17. What undissolved solid remained in the generator tube in E-2b? . _____
18. Old mortar is composed of -?- . _____ and _____
19. New mortar is composed of -?- . _____, _____, _____
20. New mortar absorbs -?- and becomes old mortar. . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 42-A

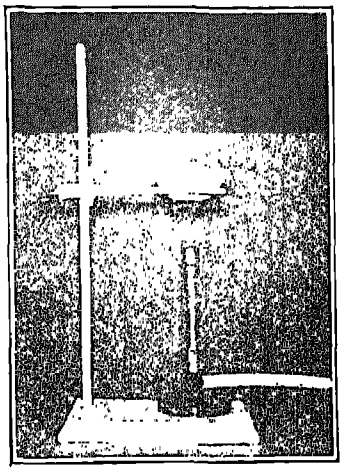
BORAX AND BORIC ACID

MATERIALS: Borax; sulfuric acid; alcohol.

APPARATUS: 4 test tubes; graduate; test-tube rack; ring-stand and ring; filter paper; litmus paper; evaporating dish; burner.

Boric acid, sometimes called boracic acid, is one of the weakest acids known. Its most important use is as a mild antiseptic, especially as an eye and mouth wash. It is prepared by the general method for preparing acids, that is, by the action of sulfuric acid on a salt (borax).

A. EXPERIMENTATION.



1-a. Pour 3 grams, 1 rounded teaspoon, of borax into a test tube, and add 10 ml. of water. Heat the tube to dissolve the salt.

b. Test the reaction of this borax solution with litmus paper.

2-a. Cautiously add 2 ml. of H_2SO_4, drop by drop, to the hot solution. Then hold the tube under running water to cool.

b. Filter the solution. Wash the precipitate, boric acid (H_3BO_3), by pouring 10 ml. of cold water through the filter.

3. Dissolve a small amount of this boric acid into 10 ml. of water.

a. Taste a drop of the solution.

b. Test its reaction.

4-a. Gently heat about ¾ of the remaining boric acid in an evaporating dish. Observe the change which takes place as the boric acid loses water to become metaboric acid, $H_2B_2O_4$.

b. Heat the dish in the hottest part of the flame, observe the change which takes place. Tetraboric acid, $H_2B_4O_7$, is formed.

5. Test for Boric Acid (Boron).

a. Place a small amount of boric acid in an evaporating dish, and add 5 ml. of alcohol. Stir the solution for a moment, and then ignite the alcohol vapors.

b. Observe the color which boron imparts to an alcohol flame.

B. OBSERVATIONS

1. What happened in A-1b? . . _____

2. Write an equation for the hydrolysis of sodium tetraborate. . _____ + _____ → _____ + _____

3. Suggest a name for this acid. . _____

4. Describe the taste and reaction of the boric acid solution. . . . . _____

5. What happened in A-4a? . . . _____

6. Write an equation for this reaction. . . . . _____ → _____ + _____

7. What happened in A-4b? . . _____

8. Write an equation for this reaction. . . . . _____ → _____ + _____

9. What is the alcohol flame test for boric acid (boron)? . . . . _____

10. Write an equation for the preparation of boric acid. . . . . _____ + _____ + _____ → _____ + _____

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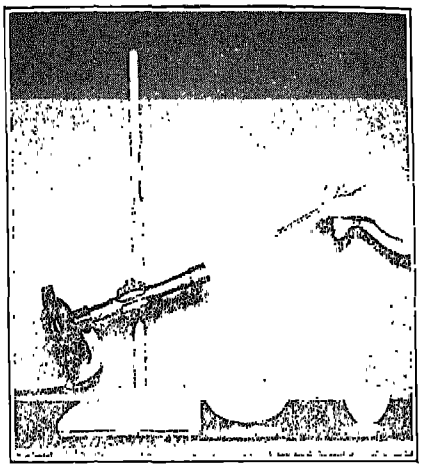
EXPERIMENT 42-B

BORAX BEAD TESTS

MATERIALS: Borax; hydrochloric acid; a salt of chromium, cobalt, copper, iron, manganese, and nickel; 4 unknowns.

APPARATUS: 2 test tubes; test-tube rack; test-tube clamp; platinum test wire; crucible; evaporating dish; ring-stand; burner.

When borax, $Na_2B_4O_7 \cdot 10H_2O$, is heated it expands, loses its water of crystallization, and fuses to a hard, transparent, colorless glass-like substance. This compound, sodium tetraborate ($Na_2B_4O_7$ or $Na_2O \cdot 2B_2O_3$), is an acid anhydride which will combine with metallic oxides to form salts. Some of these metallic borates possess characteristic colors by which their metallic ions may be identified.



A. EXPERIMENTATION.

1. Place about 3 grams, 1 level teaspoon, of borax in the crucible.
2. Make a small loop, 3 or 4 mm. in diameter, in the end of the platinum wire.
3. Clean the wire by dipping it in hydrochloric acid, about 5 ml. in a test tube, and then heating it in the hottest part of the flame. Repeat this operation until the hot wire produces no discoloration of the flame.
4. Dip the end of the hot wire into the borax and heat it in the hottest part of the flame. If the wire was clean, a transparent, glass-like bead will be formed.
5. Touch the hot bead to a speck of a chromium salt, and heat it in the oxidizing flame until the color is uniformly distributed. Then tap the wire on the edge of the evaporating dish to dislodge the bead. Record its color in the table.
6. Heat the end of the wire to redness and then plunge it into cold water, 5 ml. in a test tube. Scrape the wire between a piece of folded paper and then continue the cleaning process as in A-3.
7. Make a borax bead from a salt of each of the metals listed in the table. Record their colors.
8. Test 4 unknowns by this method. Record the number of the unknown, color of the bead, and the metal.

Metal	Color of the bead
1. Chromium	
2. Cobalt	
3. Copper	
4. Iron	
5. Manganese	
6. Nickel	

DATE..... PERIOD..... NAME.....

EXPERIMENT 43

ALUMINUM AND ITS COMPOUNDS

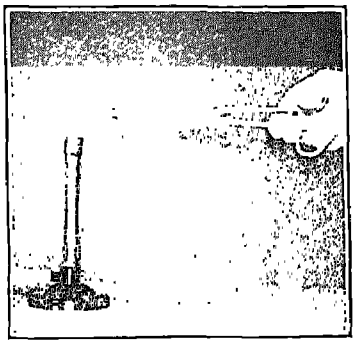
MATERIALS: Aluminum wire; aluminum turnings; aluminum powder; magnesium ribbon; ferric oxide, powdered; sodium bicarbonate; hydrochloric acid; ammonium hydroxide; sodium hydroxide 10% solution; aluminum sulfate solution; limewater.

APPARATUS: 5 test tubes; delivery tube; rubber stopper, No. 2; test-tube rack; litmus solution; litmus paper; ring-stand and ring; forceps; asbestos mat; burner.

Aluminum is the most abundant metal and the third most abundant element. Aluminum combines with oxygen with the evolution of a tremendous amount of heat. This makes it valuable as a reducing agent in metallurgy (Goldschmidt Process) and in welding (Thermite Process). Aluminum hydroxide is amphoteric, e. g., it acts as a base, $Al(OH)_3$, when in the presence of a strong acid; and it acts as an acid, $HAlO_2$, when in the presence of a strong base.

A. EXPERIMENTATION.

1. Grasp a short piece of aluminum wire, about an inch in length, with the forceps and hold it in the hottest part of a Bunsen flame.



2. Drop a small piece of aluminum turnings into a test tube, and add 5 ml. of concentrated hydrochloric acid.
   a. Test the gas by bringing a flame to the mouth of the tube.
   b. Add 15 ml. of water; divide the solution into two parts and save for A-4 and A-5.
3. Drop a small piece of aluminum turnings into a test tube, and add 5 ml. of sodium hydroxide solution. Warm the tube, if necessary, to start the action.
   a. Loosely stopper the tube for a minute. Remove the stopper and immediately bring a flame to the mouth of the tube.

4-a. Add a few drops of litmus solution to a solution of aluminum chloride, from A-2b. Note the color reaction.
   b. Add ammonium hydroxide, drop by drop, until the solution is slightly alkaline. Observe the results.
   c. Now add a few drops of hydrochloric acid.

5-a. Add sodium hydroxide to a solution of aluminum chloride, from A-2b, until you observe evidence of a reaction.
   b. Now add a few drops more of the base (an excess) and shake the tube. This illustrates the action of aluminum hydroxide in the presence of a strong base. The product is sodium aluminate.

6-a. Pour 15 ml. of aluminum sulfate solution into a test tube. Test its reaction with litmus paper.
   b. Connect a delivery tube to the test tube. Add a pinch of sodium bicarbonate and pass the gas through limewater.

7-a. Thoroughly mix a level teaspoon each of powdered iron oxide and aluminum powder on a piece of paper. Pour this mixture on an asbestos mat which is supported by a ring on a ring-stand.
   b. Place one end of a 4 or 5 cm. length of magnesium ribbon in the mixture to serve as a fuse.
   c. Stand at arm's length and ignite the magnesium ribbon with a flame. This is a thermite mixture, and produces a temperature of about 3500° centigrade.

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B. OBSERVATIONS.

1. What happened in A-1? . . . _____

2. What does this suggest about the use of aluminum cooking utensils in the home? . . . . . _____

3. What was proven by the results of A-2a? . . . . . _____

4. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

5. What was proven by the results of A-3a? . . . . . _____

6. Write an equation for this reaction. . . . . _____ + _____ → $NaAlO_2$ + _____

7. What happened in A-4b? . . _____

8. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

9. What happened in A-4c? . . _____

10. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

11. What happened in A-5a? . . _____

12. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

13. What happened in A-5b? . . _____

14. Write an equation for this reaction. . . . . $HAlO_2$ + _____ → _____ + _____

15. Write an equation to show the results of A-6a. . . . . _____ + _____ → _____ + _____

16, 17. Show how each of these products reacts with sodium bicarbonate: . .

H_2SO_4 + _____ → _____ + _____

$HAlO_2$ + _____ → _____ + _____

18. Why is aluminum sulfate used in the small compartment of foam fire extinguishers? . . . . . _____

19. Write an equation for the reaction which took place in A-7c. . _____ + _____ → _____ + _____

20. Which property of aluminum is made use of in this reaction? . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 44

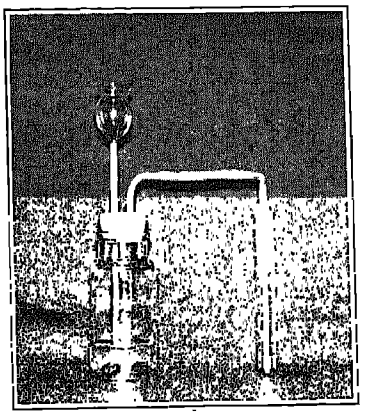
HARD WATER

MATERIALS: Marble chips; limewater; hydrochloric acid; distilled water; soap solution (liquid hand soap, diluted 1 to 5 with distilled water); solutions of calcium chloride, sodium carbonate, borax (sodium tetraborate) and sodium phosphate.

APPARATUS: Wide-mouth bottle; thistle tube; delivery tube; 5 test tubes; test-tube rack; test tube holder; funnel; filter paper; burner.

Hard water contains dissolved calcium and magnesium compounds (calcium and magnesium ions) which react with soap to form a sticky curd. Water softening is the term applied to the removal (precipitation) of these objectionable ions from water. "Temporary hard water" contains the acid carbonates of calcium and magnesium, and may be softened by boiling or by calcium hydroxide. "Permanent hard water" contains the chlorides and sulfates of calcium and magnesium, and can be softened only by the use of chemicals (water softeners).

A. TEMPORARY HARD WATER.



1-a. Pour 10 grams, 1 rounded teaspoon, of marble chips into a wide-mouth bottle and add about 20 ml. of water.

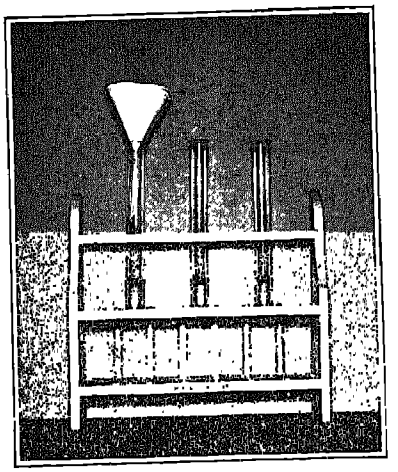
b. Assemble the apparatus.

c. Pour 5 ml. of limewater and 10 ml. of distilled water into the test tube.

d. Pour hydrochloric acid through the thistle tube in amounts sufficient to maintain a steady flow of gas. Pass carbon dioxide through the limewater for 2 or 3 minutes, and observe the two distinct changes which take place.

e. Divide the final product, calcium acid carbonate, into three equal parts.

2-a. Gently boil 5 ml. of the calcium bicarbonate solution, from A-1e, and observe the change which takes place. Filter this solution and save the filtrate for A-2c.



b. Add limewater, drop by drop with shaking, to 5 ml. of calcium bicarbonate until no further action takes place. Filter this solution and save the filtrate for A-2c.

c. Add soap solution, drop by drop with shaking, to 5 ml. of the solution from A-1e. Record the number of drops required to produce a permanent (2 minute) suds. Repeat, using the filtrates from A-2a and A-2b. Record the results in the table.

B. PERMANENT HARD WATER.

1-a. Pour 5 ml. of calcium chloride solution into each of 4 test tubes, and add an equal volume of water.

b. Add the following water softeners, drop by drop with shaking, until no further action is apparent: sodium carbonate, Na_2CO_3, solution to the first tube; borax, $Na_2B_4O_7$, solution to the second tube; and sodium phosphate, Na_3PO_4, solution to the third tube.

c. Filter each solution into a clean test tube.

d. Record the number of drops of soap solution, added drop by drop with shaking, which are required to produce a permanent suds in each of the four tubes.

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C. OBSERVATIONS.

	Exp.	Kind of Hard Water	SOFTENING PROCESS	Drops of Soap
1.	A-1e	Temporary	$Ca(HCO_3)_2$	
2.	A-2a		$Ca(HCO_3)_2 \rightarrow$ + +	
3.	A-2b		+ → +	
4.	B-1b		+ → +	
5.	B-1b		+ → +	
6.	B-1b		+ → +	
7.	B-1b		$CaCl_2$	

8. What change did you observe in A-1d? . . . . . _____

9. Write an equation for the first change observed in A-1d. . . _____ + → +

10. Write an equation for the second change observed in A-1d. . . _____ + → _____

11. Water softening is the removal of -?- from water. . . . . _____

12. Temporary hard water contains the -?-. . . . . _____

13. Temporary hard water may be softened by either -a- or -b-. . a. _____ b. _____

14. Permanent hard water contains the -?- of calcium and magnesium. . . . . _____

15. Permanent hard water may be softened by either -?-. . . . _____ , _____ , _____

16. What evidence of a chemical change did you observe in A-2a? _____

17. The results of A-2c show that temporary hard water may be softened by either -?-. . . . _____

18. The results of B-1d show that permanent hard water may be softened by either -?-. . . . . _____

19. Hard water is undesirable for washing purposes because it forms a -?-. . . . . _____

20. Why should water softeners be used when washing with hard water? . . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 45

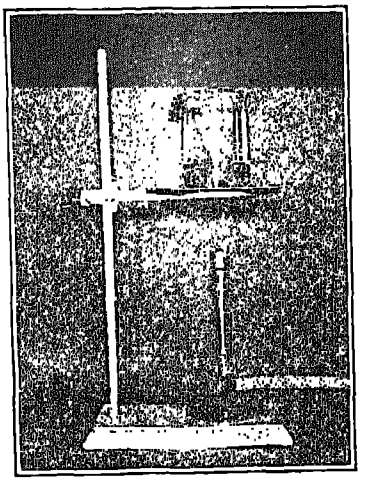
DYES AND DYEING

MATERIALS: Hydrochloric acid, 1%; tannic acid 0.1%; antimonyl potassium tartrate (tartar emetic), 0.1%; aluminum sulfate, 5% solution; ammonium hydroxide; stock solutions of Congo red, malachite green, and alizarin; white cotton cloth.

APPARATUS: 3 small beakers; 1 large beaker; scissors; ring-stand and ring; wire gauze; burner.

Coal tar (aniline) is one of the greatest sources of dyes. The dyeing process depends upon the physical as well as the chemical properties of both the cloth and the dye. Wool and silk are more chemically active and more absorbent than cotton and linen and are therefore more easily dyed. For this reason, animal fibers are suitable for direct dyeing. But, there are only a few dyes which will become permanently attached to cotton without the use of a mordant. The same dye will frequently produce different colors with different mordants.

A. SIZING.



Cloth is frequently coated with substances such as starch, paraffin, gum, magnesium chloride, etc., to give it weight and to improve its appearance. This substance, called "sizing," must be removed before the cloth can be successfully dyed.

1. Provide yourself with 9 1-inch squares of white cotton cloth and place them in 3 groups of 3 squares each. Use the scissors to snip 1 corner off each square in the second group, and 2 corners off each of the squares in the third group. This is for identification.



2. Place these 9 squares of cloth into a small beaker containing 50 ml. of hydrochloric acid, 1%. Boil gently for 5 minutes, then remove the cloth and rinse it thoroughly.

B. MORDANTING.

1. ALUMINUM HYDROXIDE.
   a. Place the 3 squares of cloth from the second group into a small beaker containing 25 ml. of aluminum sulfate, 5% solution. Gently boil the solution for 3 minutes, then remove the squares and squeeze out the excess liquid. Do not rinse them.



   b. Place these 3 squares into a small beaker containing 25 ml. of ammonium hydroxide (1 : 15). Warm the solution, but do not let it boil. After 3 minutes, remove the squares and rinse them thoroughly in cold water.
2. TANNIC ACID.
   a. Place the 3 squares of cloth from the third group into a small beaker containing 25 ml. of tannic acid, 0.1%. Boil gently for 5 minutes, then remove the cloth and squeeze out the excess liquid.



   b. Place these 3 squares into a small beaker containing 25 ml. of cold antimonyl potassium tartrate (tartar emetic), 0.1% solution. After 3 minutes, remove the squares of cloth and rinse them thoroughly in cold water.

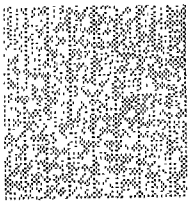
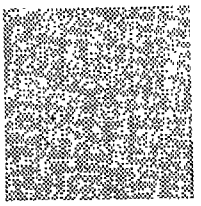
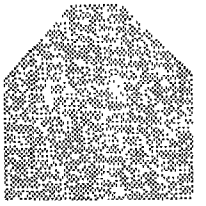
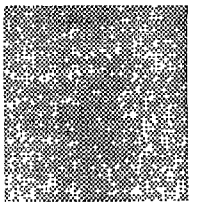
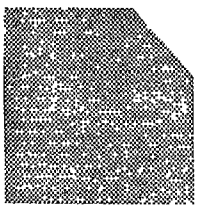
C. DYEING.

1. CONGO RED — A DIRECT DYE.
   a. Place one of each of the three different shaped squares of cloth into a small beaker containing 25 ml. of Congo red.
   b. Boil slowly for 3 minutes, stirring occasionally.
   c. Thoroughly rinse the squares of cloth in cold water, then press them out smoothly on the side of a large beaker of hot water and leave until dry.
   d. Trim the squares and mount them neatly in the proper spaces.

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2. Malachite Green — A Basic Dye.
Repeat the procedure outlined in C-1, using 25 ml. of malachite green instead of Congo red.

3. Alizarin — A Mordant Dye.
Repeat C-1, using 25 ml. of alizarin instead of Congo red.

DYE	UNMORDANTED Cotton Cloth	MORDANTED — $Al(OH)_3$ —	MORDANTED — Tannic Acid —
Congo Red			
Malachite Green			
Alizarin			

D. OBSERVATIONS.

1. What is "sizing"? . . . . . _____

2. Why are mordants used in dyeing? . . . . . _____

3. Which kinds of cloth require the use of a mordant? . . . . . _____

4. Why is Congo red called a "direct dye"? . . . . . _____

5. Why is alizarin called a "mordant dye"? . . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 46-A

TEST FOR IRON COMPOUNDS

MATERIALS: Ammonium hydroxide; solutions of ferrous sulfate (2%, freshly prepared), ferric chloride (2%), potassium ferrocyanide, potassium ferricyanide (freshly prepared), potassium sulfocyanide.

APPARATUS: 4 test tubes; test-tube rack.

Since there are two classes of iron compounds, we must be able not only to detect the presence of iron, but to determine whether it is present as the ferrous or the ferric salt or both. This may be done by one or more of the following tests. The most decisive tests will be marked with an asterisk (*) in the table below. If the test tubes are hard to clean, use a dilute solution of sodium hydroxide.

A. TEST FOR FERROUS IONS.

1. Arrange 4 test tubes in the rack, and pour 5 ml. of a freshly prepared ferrous sulfate (or any other ferrous salt) solution into each of the tubes.
2. Observe and record the colors produced immediately after the addition of each of the following reagents. Pour a few drops of:
   ammonium hydroxide into the first tube,
   potassium ferrocyanide, $K_4Fe(CN)_6$, into the second tube,
   potassium ferricyanide, $K_3Fe(CN)_6$, into the third tube, and
   potassium sulfocyanide, KSCN, into the fourth tube.

B. TEST FOR FERRIC IONS.

Repeat "A," using 5 ml. portions of a ferric chloride (or any other ferric salt) solution instead of ferrous sulfate.

C. OBSERVATIONS.

	TESTS FOR FERROUS AND FERRIC IONS	COLOR
1.	$FeSO_4 + NH_4OH \rightarrow (NH_4)_2SO_4 +$	
2.	$FeCl_3 + NH_4OH \rightarrow NH_4Cl +$	
3.	$FeSO_4 + K_4Fe(CN)_6 \rightarrow K_2SO_4 +$	
4.	* $FeCl_3 + K_4Fe(CN)_6 \rightarrow KCl +$	
5.	* $FeSO_4 + K_3Fe(CN)_6 \rightarrow K_2SO_4 +$	
6.	$FeCl_3 + K_3Fe(CN)_6 \rightarrow KCl +$	
7.	* $FeSO_4 + KSCN \rightarrow K_2SO_4 +$	
8.	* $FeCl_3 + KSCN \rightarrow KCl +$	

9. Which class of compounds produced these distinguishing colors? _____
10. Which of these tests would you use in testing for an iron compound? . . . . . Number(s): _____

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EXPERIMENT 46-B

OXIDATION AND REDUCTION

MATERIALS: Ferric chloride, 2% solution; hydrochloric acid; nitric acid; potassium sulfocyanide solution; steel wool.

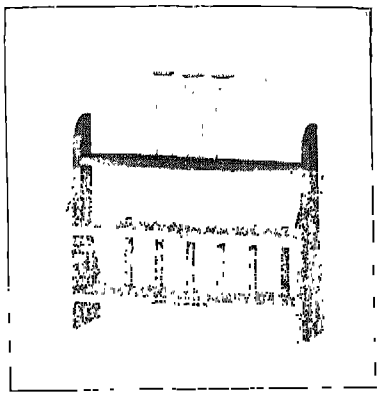
APPARATUS: 3 test tubes; test-tube holder; test-tube rack.

We have learned that oxidation takes place when oxygen combines with another element or compound. But, this is only part of the story. Oxidation takes place whenever a metallic element loses electrons (increases in valence): $Zn^{\circ} + 2HCl \rightarrow Zn^{+2}Cl_2 + H_2$

Conversely, reduction takes place whenever a metallic element gains electrons (decreases in valence): $Zn + 2H^{+1}Cl \rightarrow ZnCl_2 + H_2^{\circ}$

A. REDUCTION.

1. Pour 5 ml. of ferric chloride solution into a test tube, and add a drop of potassium sulfocyanide solution. (KSCN serves only as an indicator or test.)
2. Press a pinch of steel wool down to the bottom of the tube with a stirring rod, and then add a few drops of hydrochloric acid.
3. Heat the solution nearly to boiling and then place the tube in the rack and leave it until a complete change in color has taken place.



B. OXIDATION.

1. Pour the solution, from A-2, into a clean test tube.
2. Add 3 drops of hydrochloric acid and 1 drop of nitric acid. Observe the results.

C. OBSERVATIONS.

1. What happened in A-1? . . . _____
2. What does this prove? . . . . _____
3. What happened in A-3? . . . _____
4. What does this indicate? . . . _____
5. Complete and balance: . . . * Fe + HCl → _____ + (H)
6. Complete and balance: . . . $FeCl_3$ + (H) → _____ + _____
7. What happened in B-2? . . . _____
8. What does this prove? . . . . _____
9. What is the common name for a mixture of HCl and HNO_3? . . _____
10. Complete and balance: . . . $FeCl_2$ + (Cl) → _____

* "ous" salts are formed when metals react with non-oxidizing acids.

DATE..... PERIOD..... NAME.....

EXPERIMENT 47

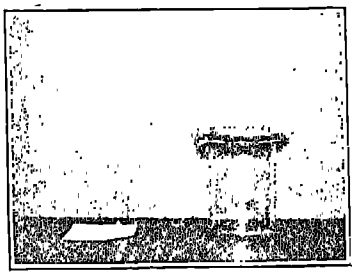
BLUEPRINTING

MATERIALS: 10% solutions of ferric ammonium citrate and potassium ferricyanide, freshly prepared; sodium hydroxide solution; 3 pieces of mimeograph or typing paper, 5 x 7 cm.

APPARATUS: Graduate; watch glass; 400 ml. beaker; 2 glass plates; paper towels.

Blueprint paper is prepared by coating one side of a piece of paper with a solution containing potassium ferricyanide and a ferric salt — ferric ammonium citrate is usually used. When dry, some object is placed over this sensitized paper and held firmly in place while it is exposed to light. Sunlight reduces the ferric salt. When put in water, the ferrous and the ferricyanide ions combine to form ferrous ferricyanide or Turnbull's blue. The unreduced ferric salt, which was beneath the object, is washed away leaving the paper white. A dilute solution of sodium hydroxide may be used as an ink on blueprint paper. This experiment must be performed in a semi-darkened laboratory. It is sufficient simply to pull the shades.

A. EXPERIMENTATION.



1. Pour 10 ml. of potassium ferricyanide into a graduate and add 10 ml. of ferric ammonium citrate, 10% solution.
2. Stopper and invert the tube a few times, then pour the solution into a watch glass.
3. Fold one corner of a piece of mimeograph or typing paper and use the folded corner as a handle to dip the paper into the solution. Be careful that there are no air bubbles between the paper and the solution, and that only one side of the paper becomes coated.
4. Sensitize two more pieces of paper, and place all three on a paper towel, in your desk drawer, to dry.
5. Fill in the back of this page while you are waiting for the blueprint paper to dry.
6. Place a piece of dry sensitized paper on a glass plate. Place a key, coin, or some other opaque object on the paper and a second glass over the object. Expose this to direct sunlight for 2 or 3 minutes.
7. Place the exposed paper, face down, in a watch glass filled with water. After about a minute, hold the paper in the palm of your hand and rinse it thoroughly in a small stream of water.
8. Press the print between a folded paper towel to remove the excess moisture, then leave it in your desk until dry.
9. Expose and develop the other two pieces of blueprint paper, using different objects if you desire. When dry, trim and mount the best print in the space at the right.
10. Write your name and date on the blueprint, using a dilute solution of sodium hydroxide (1 : 10) as an ink.

PASTE
BLUEPRINT
HERE

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B. OBSERVATIONS.

1. What is the color of the sensitized paper, in A-4? . . . . .
2. What color change occurred when the blueprint paper was exposed to light, in A-6? . . . .
3. What is the function of sunlight in this experiment? . . . .
4. What color change occurred in A-7? . . . . . .
5. What is the name of this process?
6. Give the *common name for the* colored compound which was formed in the paper. . . .
7. Give the chemical name and the formula for this compound. .
8. Show how the ions combine to form this colored compound. .
9. Why can sodium hydroxide be used as an ink on blueprint paper?

$Fe^{+2} + Fe(CN)_6^{-3} \rightarrow$

10. Complete and balance: $NaOH + \rightarrow Fe(OH)_2 +$

OXIDATION — REDUCTION EQUATIONS

	Balance the following equations. Indicate the charge of all ions which either gain or lose electrons, and write their symbols in the proper spaces at the right.	Oxidized	Reduced
	Example: $Zn^{\circ} + 2H^{+}Cl \rightarrow Zn^{+2}Cl_2 + H_2^{\circ}$	Zn	H
11.	$Al + Fe_2O_3 \rightarrow Al_2O_3 + Fe$		
12.	$CO + Fe_2O_3 \rightarrow CO_2 + Fe$		
13.	$MnO_2 + Al \rightarrow Al_2O_3 + Mn$		
14.	$Fe + HCl \rightarrow FeCl_2 + H_2$		
15.	$FeCl_2 + Cl_2 \rightarrow FeCl_3$		
16.	$FeCl_3 + (H) \rightarrow FeCl_2 + HCl$		
17.	$K_4Fe(CN)_6 + Cl_2 \rightarrow KCl + K_3Fe(CN)_6$		
18.	$FeCl_3 + H_2S \rightarrow FeCl_2 + HCl + S$		
19.	$MnO_2 + HCl \rightarrow MnCl_2 + H_2O + Cl_2$		
20.	$Zn + HNO_3 \rightarrow Zn(NO_3)_2 + H_2O + NO$		

DATE..... PERIOD..... NAME.....

EXPERIMENT 48

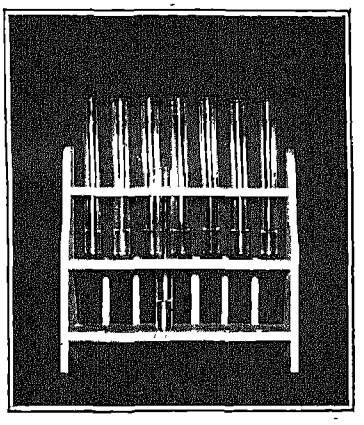
COPPER AND ITS COMPOUNDS

MATERIALS: Acetic acid, 30%; ammonium hydroxide, 25%; solutions of cupric sulfate (7%), hydrogen sulfide, potassium cyanide (2%), potassium ferrocyanide (5%), sodium hydroxide (10%); and an iron nail.

APPARATUS: 7 test tubes; test-tube holder; test-tube rack; burner.

Copper was the first metal to come into extensive use by man. This was due to the fact that it occurs free in all parts of the world in metallic masses which may be hammered into any desired shape. It is the second best conductor of electricity, for which purpose it is most extensively used at the present time. It oxidizes quite readily when heated in air, and since it is below hydrogen in the electrochemical series, non-oxidizing acids have very little effect upon it. Copper forms complex ions in the presence of an excess of certain reagents. $Cu(NH_3)_4^{+2}$ is formed when any of its bivalent salts, such as cupric sulfate, reacts with ammonia, $Cu(NH_3)_4SO_4$, or ammonium hydroxide, $Cu(NH_3)_4(OH)_2$. The color produced is characteristic of ammoniacal solutions of cupric compounds. Copper also combines with the cyanide radical to form a complex negative ion, $Cu(CN)_3^{-1}$.

A. EXPERIMENTATION.



1. Arrange 7 test tubes in the rack. Dilute 10 ml. of cupric sulfate with 25 ml. of distilled water, and pour 5 ml. of this solution into each of the test tubes.
2. Place a bright iron nail into the first tube. After a few minutes, remove the nail and observe the results. This may be used as a simple test for copper.
3. Pour 2 ml. of hydrogen sulfide solution into the second tube.
4. Pour 2 ml. of sodium hydroxide solution into the third tube.
5. Heat the contents of the fourth tube to boiling, then add 2 ml. of sodium hydroxide to the hot solution. Shake the tube and observe the results. The oxide is formed in this case.
6. Acidify the solution in the fifth tube by adding 1 ml. of acetic acid. Now add a few drops of potassium ferrocyanide. This serves as a decisive test for copper compounds.
7. Dip the pointed end of a match stick into the solution in the sixth tube and use it as a pen to write on a piece of paper. Note the color of the writing. Now hold the paper in the ammonia fumes over the mouth of an unstoppered ammonium hydroxide bottle.
8. Add 2 drops of ammonium hydroxide to the contents of the sixth tube. Shake the tube and record the results.
9. Now add an excess (2 ml.) of ammonium hydroxide to the same tube. Cupric ammonium hydroxide is formed in this case. *Caution!* Potassium cyanide is extremely poisonous. Try to avoid getting it on your hands, and as an added precaution, wash your hands thoroughly at the end of the experiment.
10. Add 2 ml. of potassium cyanide solution to the contents of the seventh tube. Shake the tube and record the results.
11. Now add 10 ml. more of potassium cyanide to the same tube. Shake the tube and again observe the results.

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B. OBSERVATIONS.

	Exp.	Results	Equation for the Reaction
1.	2.		$Fe + CuSO_4 \rightarrow$ +
2.	3.		$H_2S + CuSO_4 \rightarrow$ +
3.	4.		$NaOH + CuSO_4 \rightarrow$ +
4.	5.		$NaOH + CuSO_4 \rightarrow$ +
5.	6.		$K_4Fe(CN)_6 + CuSO_4 \rightarrow$ +
6.	7.		$NH_3 + CuSO_4 \rightarrow$ +
7.	8.		$NH_4OH + CuSO_4 \rightarrow$ +
8.	9.		$NH_4OH + CuSO_4 \rightarrow$ + +
9.	10.		$KCN + CuSO_4 \rightarrow$ +
10.	11.		$KCN + CuSO_4 \rightarrow$ +

11. Which of these reactions could be used as tests for copper? . . Exp. Nos.: _____
12. What do A-4 and A-5 indicate about the possible effect of temperature upon a reaction? . . _____
13. What is the name of the colored compound formed in A-6? . . _____
14. What do A-8, 9, 10, & 11 indicate about the possible effect of the amount of reagent upon a reaction? _____
15. Suggest a reason why copper was the first metal to be used by man. _____
16. For what purpose is copper used most extensively today? . . . _____
17. Which type of acids react with copper? Give two examples. . _____
18. Give two examples of complex ions formed by copper. . . . _____
19. What is the characteristic color of ammoniacal solutions of cupric compounds? . . . . . _____
20. Give one important physiological effect of all soluble cyanides. _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 49

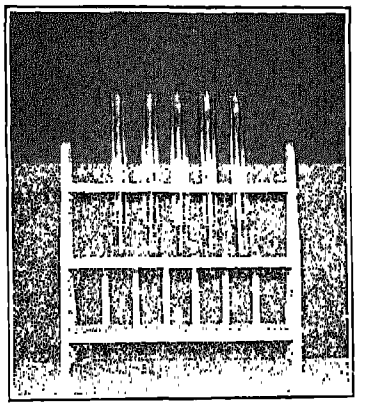
SILVER AND ITS COMPOUNDS

MATERIALS: Solutions of silver nitrate (2%), sodium potassium tartrate (2%), sodium chloride (5%), potassium bromide (5%), potassium iodide (5%), sodium hydroxide (10%), ammonium hydroxide (25%), hydrogen sulfide; nitric acid; alcohol; copper strip, about 1 cm. x 5 cm.

APPARATUS: 5 test tubes; graduate; test-tube rack; test-tube holder; watch glass; glass plate, about 5 cm. square.

Silver has been known since early times. The alchemists considered it next to gold in purity and value; and the Romans used it for ornaments and coins. It is the best conductor of heat and electricity, but it is too expensive to be used for this purpose. Silver is an inactive metal. It is not oxidized by either air or water, and non-oxidizing acids have no effect upon it. It is readily attacked by sulfur and its compounds forming the familiar black tarnish, Ag_2S, which accumulates on silverware. Silver also forms complex ions in the presence of certain reagents, such as the double cyanide $KAg(CN)_2$, which is suitable for silver plating. Metallic silver is rapidly deposited (reduced) from its halides by sunlight, especially in the presence of organic matter, such as gelatin. It is this property of silver which makes photography possible.

A. EXPERIMENTATION.



1. Arrange 5 test tubes in the rack, and pour 2 ml. of silver nitrate solution into each of them.
2. Place a polished strip of copper into the first tube. After about a minute, remove the copper and observe the results.
3. Add a few drops of hydrogen sulfide solution to the contents of the second tube. This serves as a very sensitive test for silver.
4. Add 1 ml. of:
   sodium chloride solution to the third tube,
   potassium bromide solution to the fourth tube, and
   potassium iodide solution to the fifth tube.
   Record the results in each case.
5. Expose each of these tubes, from A-4, to direct sunlight until a distinct change occurs. Record the effect of sunlight on the contents of each of the tubes.

B. SILVERING GLASS.

1. Do not touch the glass plate with your fingers from the time the cleaning process begins until after the silvering is completed. Clean the glass as follows:
   a. Scrub the glass plate, at the front desk, with a cotton swab which has been dipped into alcohol.
   b. Place the plate into the beaker of warm sodium hydroxide solution, on the front desk, and leave it until later.
2. Solution "A." Pour 1 ml. of silver nitrate solution into a test tube and dilute it with 8 ml. of distilled water. Heat to boiling and then add 1 ml. of sodium potassium tartrate solution. Gently boil this solution until a precipitate forms and turns dark gray. Filter the solution while hot.
3. Solution "B." Pour 10 ml. of silver nitrate solution into a test tube. Now add ammonium hydroxide drop by drop, shaking the tube after each addition, until the precipitate which forms at first nearly, but not completely, dissolves forming an opalescent solution.
4. Remove the glass plate from the beaker of sodium hydroxide, and rinse it thoroughly in water. Then dry and polish it with a clean cloth or paper towel. Now place the clean glass plate into a clean, dry watch glass.

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5. Mix the two solutions, "A" and "B." Pour this mixture down the side of the watch glass until the bottom, not the top, of the glass plate is completely covered. The silvering process requires from 5 to 10 minutes.
6. Rinse the watch glass with water and observe the convex surface. Clean the watch glass by dissolving the silver with a few drops of nitric acid.

C. OBSERVATIONS.

	Exp.	Color of the ppt.	REACTIONS OF SILVER IONS	A-5
1.	A-2		$AgNO_3 + Cu \rightarrow$ +	x x x
2.	A-3		$AgNO_3 + H_2S \rightarrow$ +	x x x
3.	A-4		$AgNO_3 + NaCl \rightarrow$ +	
4.	A-4		$AgNO_3 + KBr \rightarrow$ +	
5.	A-4		$AgNO_3 + KI \rightarrow$ +	
6.	B-3		$AgNO_3 + NH_4OH \rightarrow Ag_2O$ + +	
7.	B-6	x x x	$Ag + HNO_3 \rightarrow$ +	

8. What happened in A-2 ? . . _____
9. Why did this reaction occur? . _____
10. Which element was oxidized and which was reduced? . . . _____
11. What are halides? . . . . _____
12. What is the effect of sunlight on silver halides? . . . . . _____
13. Suggest a name for the precipitate formed in B-3. . . . . _____
14. Which type of chemical reaction occurred in B-5 ? . . . . _____
15. What is the function of $NaKC_4H_4O_6$ in this reaction? . _____
16. What is the appearance of the watch glass in B-6 ? . . . . _____
17. Why didn't we use hydrochloric acid in B-6 ? . . . . . _____
18. Give the name of the black tarnish which forms on silverware. . . _____
19. Why isn't silver used as a conductor of electricity? . . . . _____
20. Why are silver halides used in photography? . . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 50

THE CHEMISTRY OF PHOTOGRAPHY

MATERIALS: Solutions of silver nitrate (2%), sodium thiosulfate (25%), potassium bromide (5%), photographic developer (any commercial brand; or dissolve 5.8 grams of hydroquinone in 500 ml. of distilled water, then dissolve successively in this solution 19 grams of anhydrous sodium sulfite, and 38 grams of anhydrous sodium carbonate).

APPARATUS: 3 test tubes; graduate; test-tube rack; 3 solid rubber stoppers, No. 2; 3 pieces of dark paper, about 10 cm. x 15 cm.; 3 rubber bands.

Silver halides possess the unique characteristic of being reduced (decomposed) by light, especially in the presence of organic matter, such as gelatin. It is this property of silver halides which makes photography possible. The chemistry involved in photography is rather simple. The silver halide is exposed to light, which *starts* the reduction of the compound to finely divided metallic silver and the halide, which is liberated. Then the negative or print is immersed in the developer, which is such a mild reducing agent that it does not start the reduction, but only *continues* the reduction which was started by the light. Therefore, that portion of the silver halide which was exposed to light is reduced by the developer, while the portion which was not exposed to light remains unchanged. Also, the extent of the reduction by the developer is in direct proportion to the intensity of the light and the length of exposure. After the developer, the negative or print is placed into a sodium thiosulfate (hypo) solution which "fixes" it by dissolving all of the unreduced silver halide, thus making the negative or print permanent.

This experiment should be performed in a photographic dark room, or darken the laboratory as much as possible and use every precaution to exclude light from the reaction tubes.

A. EXPERIMENTATION.

1. Wrap dark paper around the full length of each of 3 test tubes and bind it in place with rubber bands. (Omit this step if a photographic dark room is used.)

2. Pour 5 ml. of distilled water, 1 ml. of silver nitrate solution, and 1 ml. of potassium bromide solution into each of the tubes. Stopper each of the tubes as soon as the last addition has been made.

3-a. Slip the first tube out of its paper cylinder and observe the nature of the precipitate.
b. Expose this tube to direct sunlight, or a bright artificial light, for 3 minutes. Gently stir the contents of the tube with a stirring rod during the exposure. Observe the effect of light on the precipitate, then return the tube to its paper cylinder.

4. Add 3 drops of developer to the first and second tubes, then replace the stopper as quickly as possible. Shake the tubes gently for a few seconds, then raise each of the tubes momentarily and observe the effect of the developer on the precipitate which was exposed to light as well as the one which was not exposed to light. Then quickly as possible:

5. Add 3 ml. of sodium thiosulfate (hypo) solution to each of the 3 tubes, and shake them vigorously for about 1 minute. Now remove the paper and compare the effect of the fixing solution on the contents of each tube.

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B. OBSERVATIONS.

	Exp.	Reaction	Appearance
1.	A-3a	$AgNO_3$ + KBr +	
2.	A-3b	$AgNO_3$ + KBr + light	
3.	A-4	$AgNO_3$ + KBr + light + developer	
4.	A-4	$AgNO_3$ + KBr + developer	
5.	A-5	$AgNO_3$ + KBr + light + developer + hypo	
6.	A-5	$AgNO_3$ + KBr + developer + hypo	
7.	A-5	$AgNO_3$ + KBr + hypo	

8. Write the formulas for three silver halides. . . . . _____ , _____ , _____

9. Why are silver halides used in photography? . . . . . _____

10. Write an equation for the reaction in A-2. . . . . _____ + _____ → _____ + _____

11. What is the name of this precipitate (A-2)? . . . . . _____

12. Write an equation for the reaction which is started by light, in A-3b. . . . . _____ → _____ + _____

13. What is the function of light in photography? . . . . . _____

14. What is a photographic developer? . . . . . _____ agent

15. What is the effect of the developer on the precipitate which was exposed to light? . . . . . _____

16. What is the effect of the developer on the precipitate which was not exposed to light? . . . . _____

17. What is the function of the developer? . . . . . _____

18. What is the effect of the hypo solution on the exposed, and developed precipitate? . . . . _____

19. What is the effect of the hypo solution on the unexposed, developed precipitate? . . . . . _____

20. What is the function of the hypo solution? . . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 51

PHOTOGRAPHIC PRINTING

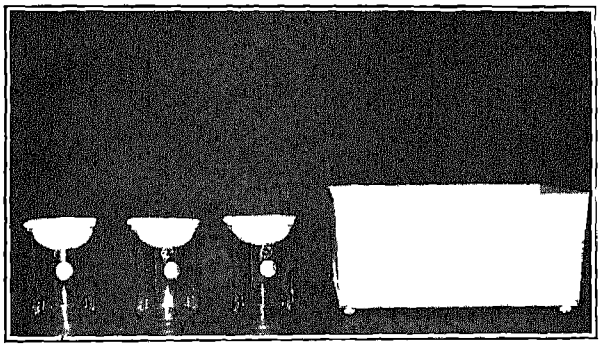
MATERIALS: 6 pieces of photographic printing paper, about 4 cm. x 5 cm.; photographic developer; sodium thiosulfate, 25% solution; acetic acid, 1.35%.

APPARATUS: 3 evaporating dishes; 3 beakers, 400 ml.; pnuematic trough; 2 glass plates, about 5 cm. square; graduate; negative; pen point and holder.

Photographic films, plates, and printing paper are all made sensitive to light by a thin coating of a silver halide (usually bromide) suspended in gelatin. This would lead us to the assumption that the same procedure would be used in photographic printing as in the preparation of a negative from a film or plate, which is absolutely true. In either case, the first step is the *exposure* of the light-sensitive compound to light, which starts its reduction. The second step is the continued *reduction* of the silver halide by the developer. As we have seen, the speed of the reduction of the silver halide by the developer is proportional to the amount of reflected light which it receives during exposure. Because of the varying intensity of the reflected light from the light and dark objects of which the picture is taken, there is a corresponding variation in the reduction of the light-sensitive compound, which results in the formation of an image on the negative or print which is composed of varying shades of black on the white paper. The third step is the dissolving of the unreduced silver compound by the hypo solution. This is called *fixing* because it renders the film or print permanent, so it may be taken into light without further reduction taking place and making the whole surface uniformly black.

Perform this experiment either in a photographic dark room, or in the laboratory after it has been darkened as much as possible. Use red or amber light as the source of necessary illumination.

A. EXPERIMENTATION.



1. Arrange the apparatus as shown at the right.
2. Pour 25 ml. of the developer into the first evaporating dish, 25 ml. of acetic acid (1.35%) into the second, and 50 ml. of sodium thiosulfate solution into the third evaporating dish. Fill the pneumatic trough with water.

3-a. Write your name, date, course and period number on the emulsion (shiny) side of a piece of the printing paper, using a hypo solution as the ink. Allow the writing to dry for about 2 minutes.

b. Expose the paper to light for about 3 seconds in a photographic exposure box, or about 15 seconds in a semi-darkened room.

c. Place the exposed paper into a developing solution, emulsion side up, for about 45 seconds. If the print darkens too quickly, the paper was over-exposed; and if it darkens too slowly, it was underexposed. If your first attempt is unsuccessful, try again.

d. As soon as the image reaches the desired shade, quickly remove the print from the developer and rinse it for a few seconds in the acid rinse bath (acetic acid). The acid instantly checks the action of the developer.

e. Immerse the print in the hypo solution, emulsion side up, and let it remain for at least 10 minutes. Prepare prints for A-4 and A-5 at this time.

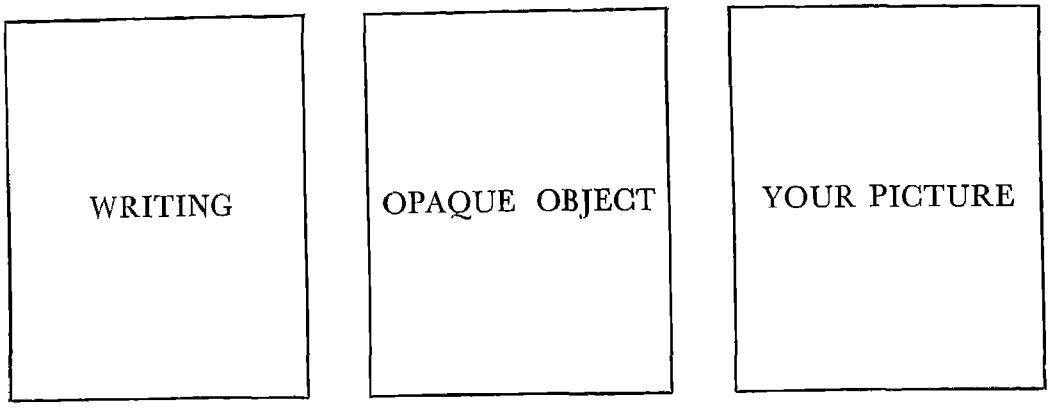
f. Transfer the print to the pneumatic trough, and let it remain in the water until the latter part of the period.

g. Dry the print, between paper towels or as directed, and then mount it in the proper space.

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4. Place an opaque object, such as a key or coin, against the emulsion side of a piece of the sensitized paper. Expose the paper and prepare the print as in A-3.

5. Place the dull side of a negative, preferably of yourself, against the emulsion side of a piece of the printing paper. Expose the paper through the negative to light in an exposure box for about 8 seconds, or sandwich the paper and negative between two clean pieces of glass and expose for about 30 seconds in a semi-darkened room. Develop, rinse, fix, dry, and mount as in A-3.



B. OBSERVATIONS.

1. What is the shiny surface on printing paper composed of? . _____

2. What process takes place during the developing of a film or a piece of sensitized paper? . . . _____

4. What change takes place in the appearance of the exposed paper while it is being developed? . . _____

5. Why is an acid rinse bath used? _____

6. What chemical change takes place during the fixing process? _____

7. Why is it necessary to "fix" negatives and prints? . . . . . _____

8. Dark areas in the negative appear as -?- areas on the print. . . . _____

9. What is the composition of the dark coloration on negatives and prints? . . . . . _____

10. What is the chemical name of the fixing solution? . . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 52

TIN AND ITS COMPOUNDS

MATERIALS: Mossy tin; hydrochloric acid; nitric acid; solutions of mercuric chloride, and hydrogen sulfide.

APPARATUS: 5 test tubes; test-tube rack; ring-stand and ring; blowpipe; charcoal block; burner.

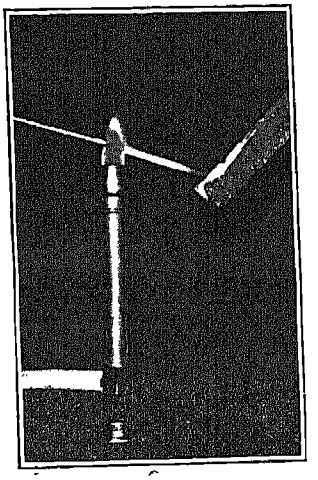
Tin is another of the common metals which was known and used by the ancients. Cassiterite, SnO_2, is its chief ore, and it is mined extensively in Wales, Bolivia, and in the Malay Peninsula. Tin is the only one of the common metals which does not occur abundantly in the United States. Tin is chiefly used in making tin cans, which really contain only a thin coating of tin, and in making alloys, such as solder, type metal, and bronze.

A. EXPERIMENTATION.

1-a. Place a small piece of tin, no larger than a pea, into the depression in a charcoal block and heat it with the oxidizing flame of a blowpipe.

b. Observe the relative temperature at which this metal melts.

c. Continue heating the molten tin, and observe any evidence of a chemical change which may appear. The "-ic" compound is formed.



2-a. Drop a small piece of tin, about the size of a pea, into a test tube which contains 3 ml. of nitric acid. If necessary, gently warm the tube to start the action. The product in this case is the hydrated oxide of tin, $SnO_2 \cdot H_2O$, which is also known as metastannic acid, H_2SnO_3. This reaction serves as a decisive test for tin.

b. When the reaction is complete, add 15 ml. of water to the tube and test to determine whether the product is soluble in water.

3-a. Drop a small piece of tin, about the size of a pea, into a test tube containing 3 ml. of hydrochloric acid. If necessary, warm the tube to start the action. Recall that "ous" salts are formed when metals react with non-oxidizing acids.

b. Pour 10 ml. of water into the tube, and use the resulting solution in the succeeding parts of this experiment.

4. Pour a few drops of hydrogen sulfide solution into a test tube containing 3 ml. of stannous chloride solution, from A-3b.

5-a. Pour a few drops of stannous chloride solution into a test tube containing 3 ml. of mercuric chloride solution. The insoluble compound is mercurous chloride; stannic chloride is also formed.

b. Gently warm the tube and add stannous chloride, in small amounts with shaking, until a globule of a silvery liquid collects in the bottom of the tube. The product is stannic chloride. This reaction serves as a decisive test for either of the reacting compounds.

6. Pour about half of the stannic chloride solution, from A-5b, into a clean test tube, then add a few drops of hydrogen sulfide solution. Compare the color of the stannic sulfide formed in this case with the color of the stannous sulfide formed in A-4.

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B. OBSERVATIONS.

1. Give the results of A-1b. . . . _____

2. What evidence of a chemical change did you observe in A-1c? _____

3. Write an equation for this reaction. . . . . _____ + _____ → _____

4. What is the appearance of the insoluble compound formed in A-2a? . . . . . _____

5. What is the name of this compound? . . . . . _____

6. Write an equation for the reaction which occurred in A-2a. . _____ + _____ → _____ + _____

7. Describe the results of A-2b. . _____

8. Write an equation for the reaction which occurred in A-3a. . _____ + _____ → _____ + _____

9. Give the name and color of the insoluble compound formed in A-4. . . . . _____ ; _____ color

10. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

11. What happened in A-5a? . . . _____

12. Write an equation for this reaction . . . . . _____ + _____ → _____ + _____

13. Show the valence changes which occurred during this reaction . . Sn: _____ to _____ ; Hg: _____ to _____

14. What is the name of the type of reaction in which valences change in this manner? . . . . . _____

15. Which element was oxidized and which was reduced? . . . . Oxidized: _____ ; Reduced: _____

16. Write an equation for the reaction in A-5b. . . . . _____ + _____ → _____ + _____

17. Show the valence changes which occurred during this reaction . . Sn: _____ to _____ ; Hg: _____ to _____

18. Give the name and color of the insoluble compound formed in A-6. . . . . _____ ; _____ color

19. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

20. How may hydrogen sulfide be used to distinguish between stannous and stannic compounds? . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 53

LEAD AND ITS COMPOUNDS

MATERIALS: 1 piece of sheet lead, about 0.5 cm. x 1 cm.; hydrochloric acid; nitric acid; sulfuric acid; solutions of hydrogen sulfide, potassium chromate, and sodium hydroxide; distilled water.

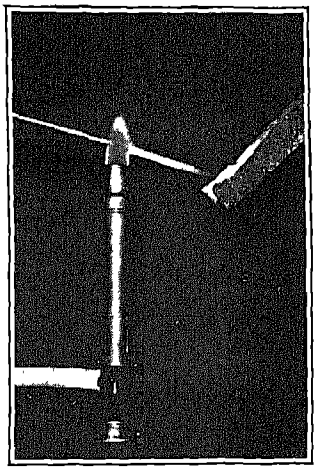
APPARATUS: 5 test tubes; graduate; test-tube rack; ring-stand and ring; charcoal block; burner; blowpipe.

Lead was known and used by the Egyptians, Babylonians, and the Romans. Galenite, PbS, its chief ore, occurs abundantly in many parts of the world, and especially in the United States. Huge quantities of this metal are used in making storage batteries, paints, and alloys; and its compounds find extensive use in industry. When working with lead we must remember that all soluble lead compounds are poisonous and that their effect is cumulative, that is, small amounts which are taken into the body from time to time remain in the system, gradually increasing the total amount of the poisonous compounds in the body and thus increasing its poisoning effect.

A. EXPERIMENTATION.

1-a. Cut a piece of lead in half with a knife. Note the ease with which this metal may be cut.

b. Observe the appearance of the freshly cut surface of the lead.



2-a. Place a piece of lead into the cavity in a charcoal block and heat it with the oxidizing flame of a blowpipe.

b. Observe the relative melting temperature of lead.

c. Continue heating the molten metal and observe any evidence of a chemical change which may appear.

3-a. Drop the second piece of lead into a test tube containing 4 ml. of nitric acid (1 : 1). Warm the tube gently, if necessary, to start the action. Then place it under the hood, or on the sill by an open window.

b. When the reaction is complete, dilute to 25 ml. with distilled water, and use the resulting solution in the succeeding parts of this experiment.

4. Arrange 5 test tubes in the rack, and pour 5 ml. of lead nitrate solution, from A-3b, into each of the tubes.

a. Add a few drops of hydrogen sulfide solution to the first tube.

b. Add a few drops of sulfuric acid to the second tube.

c. Add a few drops of potassium chromate solution to the contents of the third tube.

d. Add a few drops of hydrochloric acid to the fourth tube.

e. Warm the fourth tube, and observe the results. Now cool the tube by holding it in running water. Note the results.

f. Add a few drops of sodium hydroxide solution to the fifth tube.

g. Add sodium hydroxide solution, in small amounts with shaking, to the fifth tube until a second change occurs. Sodium plumbite, Na_2PbO_2, is formed in this case.

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B. OBSERVATIONS.

1. What is the appearance of freshly cut lead? . . . . . _____

2. Why does the appearance of freshly cut lead change on standing? . . . . . _____

3. How does the melting temperature of lead compare with that of most other metals? . . . . . _____

4. State the results of A-2c. . . _____

5. Why was the test tube, in A-3a, placed under the hood or in an open window? . . . . . _____

6. What is the name of the gas formed in A-3a? . . . . . _____

7. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

8. What happened in A-4a? . . _____

9. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

10. What happened in A-4b? . . . _____

11. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

12. What happened in A-4c? . . . _____

13. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

14. What happened in A-4d? . . . _____

15. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

16. What does A-4e show us about the comparative solubility of $PbCl_2$ in hot and cold water? . . _____

17. What happened in A-4f? . . . _____

18. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

19. What happened in A-4g? . . . _____

20. Write an equation for this reaction. . . . . _____ + _____ → _____ + _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 54

COLLOIDAL SUSPENSIONS

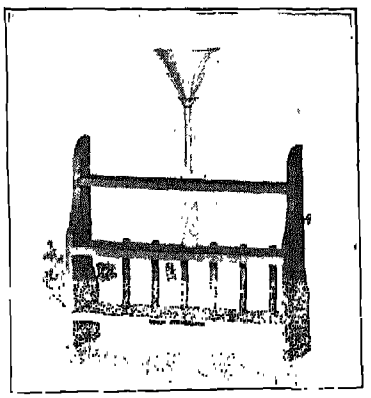
MATERIALS: Solutions of stannous chloride (5%), ferric chloride, sodium phosphate, and auric chloride. To prepare a stock solution of auric chloride, dissolve a sheet of gold foil in 8 ml. of aqua regia; then dilute the resulting solution to 200 ml. with distilled water.

APPARATUS: 5 test tubes; test-tube rack; test-tube holder; filter paper; funnel; ring-stand and ring; burner; beam of light; graduate.

A colloid is any form of matter (solid, liquid, or gas) which is pulverized to such an extent that its particles are too small to be seen even with the most powerful compound microscope, and yet they are many times larger than the particles (molecules) in a "true" solution. The colloid, in a colloidal suspension, corresponds to the solute in a solution, and the dispersing medium corresponds to the solvent. Unlike true solutions, the properties of colloidal suspensions are determined more by the size of the particles than by their composition.

A. COLLOIDAL GOLD.

1. Add 1 drop of stannous chloride solution to a test tube containing 5 ml. of auric chloride solution. Mix the chemicals by shaking the tube for a moment with a gentle to-and-fro motion. Finely divided gold is thrown out of solution in a colloidal form, due to the reducing action of stannous chloride.
2. Pass a small beam of light through this suspension. This effect is called a Tyndall cone, and shows that the colloidal particles are large enough to reflect light.
3. Pass a beam of light through a stock solution of sodium phosphate.
4. Filter the colloidal suspension, from A-2, into a second tube.
5. Place the tube containing the filtrate into the rack and leave it until the latter part of the period to see whether the colloidal particles will settle out of the dispersing medium on standing.



B. COLLOIDAL FERRIC HYDROXIDE.

1. Pour 10 ml. of distilled water into a test tube and heat it to boiling. Now add 1 or 2 drops of ferric chloride solution. Ferric hydroxide is formed during hydrolysis, and being insoluble in water the molecules begin to combine to form the insoluble solid. But, when they reach colloidal size, they become positively charged, and since like charges repel each other, the particles are prevented from further growth, and incidentally, from forming a precipitate.
2. Test this colloidal suspension of ferric hydroxide with a beam of light for the Tyndall effect.
3. Filter the colloidal suspension.
4. Add 10 ml. of distilled water to the filtrate, and divide it into two equal parts, "A" and "B."
   a. Place "A" in the rack and leave it until the latter part of the period to see whether the particles will settle out on standing.
   b. Add 1 ml. of sodium phosphate solution to "B" and place it in the rack to see whether the particles will settle out on standing.

   The negative ions of the solution discharge the positively charged colloidal particles of ferric hydroxide, thus permitting them to continue their growth. Any other electrolyte would have produced the same effect.

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C. OBSERVATIONS

1. What is a colloid? . . . . . _____

2. What is the general name of the particles in a solution? . . . _____

3. How do the particles in a solution and in a colloidal suspension compare in size? . . . . . _____

4. The solute in a solution corresponds to the -?- in a colloidal suspension. . . . . _____

5. The solvent in a solution corresponds to the -?- in a colloidal suspension . . . . . _____

6. The properties of a solution are determined almost entirely by the -?- of the solute. . . . . _____

7. The particles of a colloidal suspension are determined almost entirely by the -?- of the colloidal particles. . . . . _____

8. What is the color of your colloidal gold suspension? . . . _____

9. Complete and balance the equation for this reaction. . . . . $SnCl_2 + AuCl_3 \rightarrow \quad +$ _____

10. What happened in A-2? . . . _____

11. What happened in A-3? . . . _____

12. What happened in A-4? . . _____

13. State the results of A-5. . . . _____

14. What is the color of your colloidal ferric hydroxide? . . . _____

15. Write an equation for this hydrolysis reaction. . . . . $\quad + \quad \rightarrow \quad +$ _____

16. State the results of B-2. . . . _____

17. State the results of B-3. . . . _____

18. What happened in B-4a? . . . _____

19. What happened in B-4b? . . _____

20. Why did this happen? . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 55

SOLS, GELS, AND EMULSIONS

MATERIALS: Vinegar, or acetic acid (4%); nitric acid; egg white; milk; gelatin; kerosene; soap granules or chips; soap solution (liquid hand soap diluted 1 : 5 with distilled water).

APPARATUS: 5 test tubes; graduate; test-tube rack; test-tube holder; 2 beakers, 400 ml.; ring-stand and ring; wire gauze; burner; source of a beam of light.

As we have seen, a colloid is a state of division in which any form of matter may exist. These colloids form many different kinds of suspensions, among the most important of which are sols, gels, and emulsions. A sol is a suspension of a colloidal solid in a liquid, such as egg white, mucilage and India ink. A gel is a sol which "sets" on cooling, such as jello, meat jelly, and glue. A reversible gel will change back to the sol when the temperature is raised; and an irreversible gel is one which is permanent. An emulsion is a suspension of colloidal droplets of one liquid in another liquid, such as oil in water, and french dressing. A permanent emulsion contains a third substance, called an emulsifying agent, which prevents the two liquids from separating, such as milk, mayonnaise, and salad dressing.

A. GELATIN.

1. Pour 0.7 grams (¼ level teaspoon) of gelatin into a clean, dry test tube and then add 5 ml. of boiling water. Stir the contents of the tube until all of the gelatin has dissolved.
2. Pass a beam of light through the clear liquid.
3. Place the tube into a beaker of cold water. After about 5 minutes, remove the tube and observe the results. You should proceed with "B" while you are waiting for the tube to cool.
4. Now place the tube into a beaker of hot water. After about 2 minutes, remove the tube and observe the results.

B. EGG ALBUMEN

1. Pour 1 ml. of egg white into a test tube containing 10 ml. of cold water. Shake the tube vigorously and note the results.
   a. Test the liquid for the Tyndall effect.
   b. Place the tube into a beaker of cold water. After at least 5 minutes, remove the tube and observe the results.
2. Divide the contents of the tube into two equal parts, "A" and "B."
   a. Place "A" into a beaker of hot water. After at least 2 minutes, remove the tube and observe the results.
   b. Now place "A" into a beaker of cold water. After at least 5 minutes, remove the tube and note the results.
   c. Add 5 or 6 drops of nitric acid to "B." Mix the contents of the tube by stirring; note the results. Nitric acid is an electrolyte.

C. SOAP.

1. Pour 0.5 grams (¼ teaspoon) of soap granules or chips into a clean, dry test tube, then add 5 ml. of boiling, distilled water. Stir the contents of the tube until all the soap dissolves.
2. Test this liquid for the Tyndall effect.
3. Place the tube in a beaker of cold water. After about 5 minutes, remove the tube and observe the results.
4. Now place the tube into a beaker of hot water. Remove the tube, after about 2 minutes, and note the results.

D. KEROSENE IN WATER.

1. Pour 1 ml. of kerosene and 10 ml. of water into each of 2 test tubes. Now add 2 ml. of soap solution to the second tube.
2. Stopper the tubes and shake them vigorously. Observe the results.
3. Compare the appearance of the tubes after they have remained in the rack for 5 minutes.

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E. MILK.

1. Pour 5 ml. of milk into a test tube. Shake the tube with a gentle to-and-fro motion, and note the appearance of the milk which slushes up on the sides of the tube.
2. Add 1 ml. of vinegar, or 4% acetic acid, to the tube. Shake the tube as before, and *again* observe the appearance of the milk. Milk is an emulsion of butter in water with casein as the emulsifying agent.

F. OBSERVATIONS.

1. Give the results of A-2. . . . _____
2. What does this prove about the nature of the liquid? . . . . _____
3. What happened in A-3? . . . _____
4. Substances which behave in this manner are called -?-. . . . _____
5. What happened in A-4? . . . _____
6. This indicates that gelatin forms a(n) -?- with water. . . . . _____
7. What happened in B-1? . . . _____
8. This is another characteristic of -?- . . . . . _____
9. B-1a proves that egg white forms a(n) -?- with water. . . . . _____
10. What did we prove by the results of B-2a and B-2b? . . . . . _____
11. What happened in B-2c? . . . _____
12. What do the results of C-2 prove about soap in water? . . . . _____
13. What happened in C-3? . . . _____
14. What happened in C-4? . . . _____
15. These results show that soap and water will form a(n) -?-. . . _____
16. What class of substances is formed in D-2? . . . . . _____
17. What happened in the first tube, in D-3? . . . . . _____
18. What happened in the second tube, in D-3? . . . . . _____
19. What was the function of the soap solution? . . . . . _____
20. What effect do electrolytes have on permanent emulsions, as illustrated in E-2? . . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 56

CARBOHYDRATES: THE SUGARS

MATERIALS: Sucrose; Fehling's solution; hydrochloric acid; solutions of glucose (or corn syrup) 5%, and sodium carbonate.

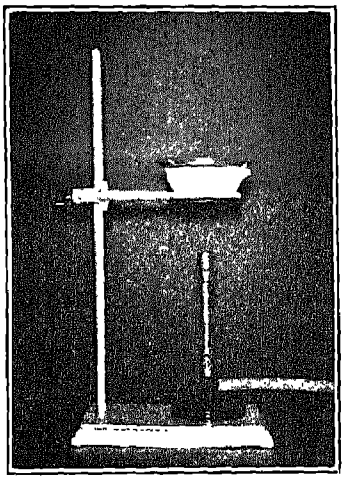
APPARATUS: 5 test tubes; graduate; test-tube clamp; test-tube holder; evaporating dish; watch glass; beaker; burner; ring-stand and ring; wire gauze.

Carbohydrates are organic compounds which are composed only of the elements carbon, hydrogen, and oxygen. The last two elements occur in the same ratio as in water; that is, twice as much hydrogen as oxygen. The most familiar examples of this class of compounds are the sugars, starches, and cellulose. Table sugar or sucrose, $C_{12}H_{22}O_{11}$, is a disaccharide, and must be broken down into simple sugars or monosaccharides, $C_6H_{12}O_6$, before it can be taken into the blood stream and used by the body. This process, which is called hydrolysis, takes place when sucrose, or any other of the disaccharides, is heated in the presence of an acid. During digestion, hydrolysis of the disaccharide is brought about by the action of the enzyme (organic catalyst) ptyalin, in the saliva.

Prepare 20 ml. of Fehling's solution, for use in this experiment, by mixing 10 ml. each of Fehling's solutions "A" and "B," in a test tube.

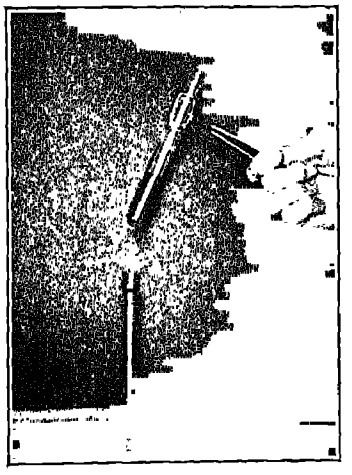
A. COMPOSITION.

1. Assemble the apparatus.
2. Pour 1 gram (¼ teaspoon) of sucrose into the evaporating dish. Now cover the mouth of the dish with a watch glass.
3. Heat the evaporating dish very gently, with a small flame. Observe the bottom of the watch glass very closely and you will see one of the products of the decomposition of sugar.
4. Remove the watch glass. Continue heating the dish, a little more intensely, for a few minutes or until only a dry, porous solid remains in the dish. This is the second product of the decomposition of sugar.
5. To clean the dish, scrape out as much of the residue as possible. Add 1.5 grams (¼ teaspoon) of potassium chlorate. Now heat the dish intensely until all of the sugar residue has disappeared. When the dish is cool, wash and dry it in the usual manner.



B. TEST FOR SIMPLE SUGARS (Monosaccharides), $C_6H_{12}O_6$.

1. Pour 5 ml. of Fehling's solution into a test tube, and heat it nearly to boiling.
2. Add a few drops of glucose, and continue the heating for a few moments longer. This color serves as a positive test for monosaccharides.



C. SUCROSE, $C_{12}H_{22}O_{11}$ (A Disaccharide).

1. Dissolve 0.5 grams (1/8 teaspoon) of sucrose in 10 ml. of water in a test tube.
2. Test a few drops of this sugar solution with Fehling's solution.
3. Add 5 drops of hydrochloric acid to the sugar solution, and place the tube in a beaker of boiling water.
4. After at least 5 minutes, remove the tube and cool it in running water.

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5. Neutralize the sugar solution by adding sodium carbonate solution, drop by drop, until no further effervescence occurs upon the addition of the reagent, and the solution is just alkaline to litmus.
6. Test again with Fehling's solution.

D. OBSERVATIONS

1. What happened in A-3? . . . _____
2. Name one product formed by the decomposition of sugar. . . . _____
3. Describe the appearance of the residue in A-4. . . . . _____
4. Name another product formed by the decomposition of sugar. _____
5. Write an equation for the decomposition of sucrose. . . . . _____ → _____ + _____
6. Show, by means of an equation, the effect of heat on potassium chlorate. . . . . _____ → _____ + _____
7. Show, by an equation, how one of these products cleaned the sugar residue out of the dish. . . _____ + _____ → _____
8. What color was produced with Fehling's solution, in B-2? . . _____
9. What happened in C-2? . . . _____
10. What does this prove? . . . . _____
11. Write an equation for the reaction in C-5. . . . . _____ + _____ → _____ + _____
12. What happened in C-6? . . . _____
13. What did you prove by this test? _____
14. Write an equation for the hydrolysis of sucrose. (The acid acts only as a catalyst). . . . . _____ + _____ → _____
15. What is a monosaccharide? . . _____
16. What is a disaccharide? . . . _____
17. Which of these classes of sugars can be used by the body without being digested? . . . . . _____
19. What is the chemical name for the process which takes place when sugars are digested? . . . _____
20. What is an enzyme? . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 57

CARBOHYDRATES: THE STARCHES

MATERIALS: Flour; starch paste; hydrochloric acid; Fehling's solution; iodine test solution; sodium carbonate, saturated solution.

APPARATUS: 5 test tubes; graduate; evaporating dish; beaker; funnel; ring-stand and ring; stirring rod; filter paper; wire gauze; test-tube rack; test-tube holder; burner; litmus.

Starch is the digestible carbohydrate which is manufactured by all plants which have green leaves. It is particularly abundant in such foods as grains and cereals, potatoes and roots, vegetables. The simplest formula for starch is $(C_6H_{10}O_5)n$, "n" being an unknown multiple. Since it is non-volatile and insoluble, its correct formula can not be determined. Even though starch is an important food, it must be changed into soluble compounds before it can be used by the body. During digestion, two enzymes, ptyalin in the saliva and amylopsin in the pancreatic juice, change starch to glucose, a monosaccharide. The same process (hydrolysis) can be made to take place in the laboratory by the catalytic action of acids. When starch is heated at 200° C., it breaks down to form dextrin, whose simplest formula is the same as that of starch. The formation of this compound, which tastes better and is more easily digested, is the real reason for toasting bread.

A. STARCH IN WATER.

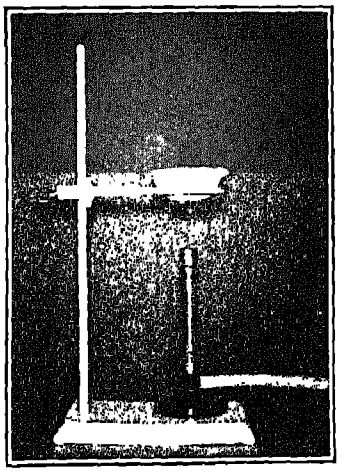
1. Pour 10 ml. of starch paste into a test tube and test it for the Tyndall effect.
2. Test 1 ml. of starch paste with Fehling's solution.
3. Now add 1 drop, not more, of iodine test solution to the remainder of the starch paste. Stir the mixture and observe the results. This color with iodine serves as a positive test for starch.

B. DIGESTION OF STARCH.

1. Hold 1 ml. of starch paste in your mouth for at least 2 minutes.
   The change in taste is due to the action of ptyalin, in the saliva, upon the starch.

C. HYDROLYSIS OF STARCH.

1. Pour 5 ml. of starch paste and 0.5 ml. (8 drops) of hydrochloric acid into a test tube. Place the tube in a beaker of boiling water, and let it remain for at least 10 minutes and longer if time permits. Continue with "D" while waiting.
2. Remove the tube and cool it in running water.
3. Neutralize the solution by adding sodium carbonate solution, drop by drop, as long as effervescence occurs, and until the solution is just alkaline to litmus. Commercial glucose (corn syrup) is made in a similar manner.
   a. Perform the Fehling's solution test.
   b. Perform the starch-iodine test.



D. STARCH TO DEXTRIN.

1. Pour 1.2 grams (½ teaspoon) of flour into an evaporating dish. Heat the dish with a very small flame. Stir the flour constantly, being careful that it does not scorch or burn. The flour (starch) will change to dextrin in from 5 to 10 minutes, as indicated by a distinct change in color.
2. Test the taste of the dextrin.
3. Dissolve about 0.3 grams (1/8 teaspoon) of dextrin in 15 ml. of warm water. Filter the resulting solution.
   a. Test about 1 ml. of the filtrate with Fehling's solution.

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b. Add 1 drop of iodine test solution to the remainder of the filtrate, and stir the mixture. This color with iodine serves as a test for dextrin. Some dextrins produce other colors.

E. OBSERVATIONS.

1. What kind of plants make starch? _____
2. Why can't we determine the correct formula for starch? . . . _____
3. What is an enzyme? . . . . _____
4. What did you prove by the results of A-1? . . . . . _____
5. What happened in A-2? . . . _____
6. What happened in A-3? . . . _____
7. What happened in B-1? . . . _____
8. Write an equation for this chemical change. . . . . _____ + _____ → _____
9. Hydrolysis within the body, by the action of enzymes, is called -?- _____
10. Write an equation for the neutralization reaction in C-3. . . _____ + _____ → _____ + _____
11. What happened in C-3a? . . _____
12. What does this prove? . . . _____
13. What happened in C-3b? . . _____
14. What does this prove? . . . _____
15. What was the function of hydrochloric acid in C-1? . . . . _____
16. Write an equation for the reaction which took place in C-1. . _____ + _____ → _____
17. What is the color of the dextrin, in D-1? . . . . . _____
18. Describe the taste of dextrin. . _____
19. What did you prove by the results of D-3? . . . . . _____
20. What color was produced by the action of iodine on dextrin? . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 58

DISTINGUISHING TESTS FOR TEXTILE FIBERS

MATERIALS: 1 cm. x 2 cm. strips of cotton, linen, rayon, silk, and wool; hydrochloric acid; sulfuric acid; sodium hydroxide, 10% solution.

APPARATUS: 6 test tubes; graduate; beaker, 400 ml.; stirring rod; microscope; tweezers; burner; ring-stand and ring; wire gauze.

The woody fibers of plants are composed chiefly of cellulose. Filter paper and absorbent cotton are almost pure cellulose. Its simplest formula is $(C_6H_{10}O_5)n$, the same as starch. Even though their simplest formulas are identical, we have reason for believing that cellulose molecules are much larger and more complicated than starch molecules. Cotton and linen are cellulose fibers. The distinguishing characteristics of these fibers are determined to a great extent by the particular source of the cellulose. Silk and wool are protein fibers of animal origin. The difference in appearance of silk and cotton is due more to the difference in the mechanical structure of the fibers than to their chemical composition. Rayon is a comparatively new textile fiber. Cotton and spruce wood are the principal sources of the cellulose from which it is made. It is not an imitation, but a product of the laboratory, having a very fine silk-like appearance.

A. MICROSCOPE TEST.

1. Examine samples of cotton, linen, rayon, silk, and woolen cloth under a compound microscope (about 80 diameters).
2. Make drawings of each of these textile fibers in the proper space in the table. Show the distinguishing characteristics in the appearance of the separate fibers, and not the pattern in which the threads are woven. Microscopic examination is the best method for identifying the various textile fibers in cloth.

B. BURNING TEST.

1. Grasp a strip of cotton cloth with the tweezers and ignite it in the flame of a Bunsen burner. Remove the cloth from the Bunsen flame as soon as it begins to burn.
2. Record the rate at which the cloth burns (as fast or slow), the nature of the flame, the odor, and the appearance of the ash.
3. Repeat this test, using successively, samples of linen, rayon, silk, and woolen cloth.

C. SODIUM HYDROXIDE.

1. Arrange 5 test tubes in the rack. Use the stirring rod to press a small strip of cotton cloth to the bottom of the first tube. In like manner, press strips of linen, rayon, silk, and woolen cloth successively into the four remaining tubes.
2. Add 5 ml. of 10% sodium hydroxide solution to each of the tubes. Now arrange the tubes in a beaker of boiling water in such a way that you can identify them later.
3. Observe the tubes occasionally for 10 minutes. Record the comparative effect of the lye solution on each of the five fabrics.

D. HYDROCHLORIC ACID.

1. Repeat C-1.
2. Pour 5 ml. of hydrochloric acid into each of the tubes.
3. Observe the tubes occasionally for 10 minutes. Record the comparative effect of the acid on each of the five fabrics.

E. SULFURIC ACID.

1. Press small, new samples of cotton and linen cloth, of equal size, into separate test tubes, as in C-1.

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2. Pour 5 ml. of concentrated sulfuric acid into each of the tubes.
3. After about 2 minutes, flush each tube with water and recover the pieces of cloth. Keep the samples separate while you rinse them, first in water and then with limewater.
4. Record the comparative effect of the acid on cotton and linen.

F. OBSERVATIONS.

	Test	Cotton	Linen	Rayon	Silk	Wool
1.	Microscope					
2.	Burning rate					
3.	Flame					
4.	Odor					
5.	Ash					
6.	NaOH					
7.	HCl					
8.	H_2SO_4			x x x	x x x	x x x

9. Which of these textile fibers are obtained from plants? . . . _____
10. Which of these textile fibers are of animal origin? . . . . _____
11. Which is the best test for the different textile fibers? . . . _____
12. Under the microscope, rayon looks something like ·?·. . . . _____
13. The burning test for rayon is similar to that of ·?·. . . . _____
14. Which are more affected by acids, animal or plant fibers? . . . _____
15. Which are more affected by bases, animal or plant fibers? . . . _____
16. How can you distinguish between animal and plant fibers? . . . _____
17. How can you distinguish between cotton and linen? . . . . _____
18. How can you distinguish between silk and wool? . . . . . _____
19. How can you distinguish between silk and rayon? . . . . _____
20. Which of these fibers would be injured by washing with strong (free alkali) soaps? . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 59

THE REMOVAL OF SPOTS AND STAINS

MATERIALS: Hydrochloric acid; oxalic acid, 5%; ammonium hydroxide, 5%; Javelle water; carbon tetrachloride (Carbona or Energine); soap.

APPARATUS: Evaporating dish; beaker, 400 ml.; medicine dropper; glass rod; paper towels; strips of muslin stained with grease, coffee, and ink; 1 strip of black woolen cloth, about 5 cm. x 10 cm.

Spots and stains may be removed by either of three general methods: FIRST, by dissolving the spot in a suitable solvent – a purely physical process. In such cases it is necessary to place some absorbent material under the spot to absorb the solvent after it has dissolved the stain, otherwise a ring of the stain will be formed as the solvent evaporates. Carbon tetrachloride (Carbona or Energine) is one of the safest solvents for oil, and grease. SECOND, by converting the stain into soluble compounds so they may be removed with soap and water. Dilute acids and bases are used for this purpose. And, THIRD, by bleaching the stain. Hydrogen peroxide and Javelle water (sodium hyposulfite) are satisfactory bleaches. Before using a chemical stain remover on a colored fabric you should test it on a small sample or on an inconspicuous portion of the fabric to determine its effect on the dye.

CAUTION: Oxalic acid is poisonous!
Do not use Javelle water on silk or wool!
Thoroughly rinse all chemicals out of the fabric!

STAIN	COTTON AND LINEN	SILK AND WOOL
Acid	Ammonium hydroxide, 5%.	Ammonium hydroxide, 5%.
Blood	1. Soak in cold water. 2. Wash in cold soapy water. 3. Javelle water.	1. Sponge with cold water. 2. Sponge with alcohol, 50%.
Cocoa Coffee Chocolate	1. Hot water. 2. Wash in hot soapy water. 3. Javelle water.	1. Sponge with warm water. 2. Carbon tetrachloride. 3. Hydrogen peroxide.
Fruit juice	1. Run boiling water through the stain. 2. Javelle water.	1. Sponge with warm water. 2. Hydrogen peroxide. 3. Acetic acid, 5% (vinegar).
Grass Vegetable	1. Wash in cold soapy water. 2. Javelle water.	1. Sponge with alcohol, 50%. 2. Hydrogen peroxide.
Grease Cream, milk	1. Wash in hot soapy water. 2. Carbon tetrachloride.	1. Carbon tetrachloride. 2. Hydrogen peroxide.
Ink	1. Wash in cold water. 2. Oxalic acid (lemon juice). 3. Javelle water.	1. Alcohol, 50%. 2. Oxalic acid, 5%.
Iodine	1. Sponge with ammonium hydroxide, 5%. 2. Wash in hot soapy water.	1. Steam the spot. 2. Sponge with alcohol, 50%.
Iron rust	Oxalic acid.	Oxalic acid.
Tar Paint Varnish	1. Sponge with turpentine, or carbon tetrachloride. 2. Wash in hot soapy water.	1. Sponge with turpentine, or carbon tetrachloride. 2. Sponge with alcohol, 50%.

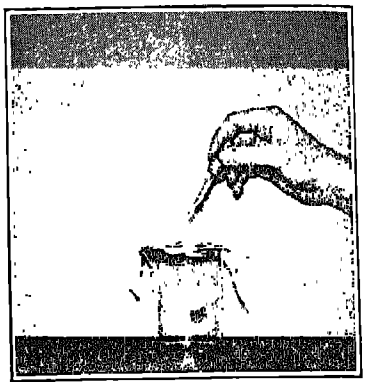
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A. GREASE SPOTS.

1. Place a piece of white blotting paper, or a folded paper towel, on a flat surface. Now place the grease spot on this absorbent material.
2. Saturate a small piece of cloth (gauze) or sponge with carbon tetrachloride (Carbona or Energine). Apply this solvent by brushing the spot with short strokes, from outside to center. This prevents the spot from spreading out and forming a ring.
3. Place the cloth on some absorbent material (towel) to dry.

B. INK SPOTS.

1. Stretch the cloth containing the dry ink spot over an evaporating dish or a beaker.
2. Run hot water through the spot until its effect has apparently ceased.
3. Use a clean eye dropper to apply oxalic acid, drop by drop, until its effect has apparently ceased, or until the spot has disappeared.
4. If a stain remains, apply Javelle water with a clean eye dropper, as in B-3.
5. Rinse the cloth thoroughly to remove the chemicals.



C. COFFEE STAINS.

1. Stretch the stained cloth over an evaporating dish or beaker.
2. Apply hot water to the stain, as in B-2.
3. Apply Javelle water, drop by drop, until the stain disappears.
4. Run water through the cloth to remove the chemicals.

D. ACID SPOTS.

1. Use a glass rod to place a drop of hydrochloric acid (1 : 4) on a strip of dark woolen cloth.
2. Use a clean eye dropper to apply ammonium hydroxide to the spot.
3. Run water through the cloth to remove the chemicals.

E. OBSERVATIONS.

1. Why was blotting paper, or a paper towel, used in A-1? . . _____
2. Why was the solvent applied from outside to center, in A-2? _____
3. What happened in B-2? . . . _____
4. If the stain had not been removed in C-2, what would have been your next step? . . . . . _____
5. What happened in D-1? . . . _____
6. What happened in D-2? . . . _____
7. What should we remember when using oxalic acid? . . . . . _____
8. What should we remember about the use of Javelle water? . . . _____
9. Strong soaps and alkalies should not be used on -?- fabrics. . . _____
10. What should we do before attempting to remove stains from colored fabrics? . . . . . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 60

ALCOHOLS AND ESTERS

MATERIALS: Amyl alcohol; ethyl alcohol; methyl alcohol; sodium acetate; acetic acid, 30%; butyric acid; salicylic acid; sulfuric acid; sodium hydroxide solution; iodine-potassium iodide solution; limewater.

APPARATUS: 3 test tubes; beaker, 400 ml.; wide-mouth bottle; test-tube holder; test-tube rack; wire gauze; ring-stand and ring; burner.

Alcohols are formed when one or more hydroxyl, OH, groups are substituted for one or more hydrogen atoms in hydrocarbons. Two of the most familiar examples of this class of compounds are methyl (wood) alcohol and ethyl (grain) alcohol. Ethyl alcohol is used extensively as a solvent and in the manufacture of synthetic perfumes and flavoring extracts.

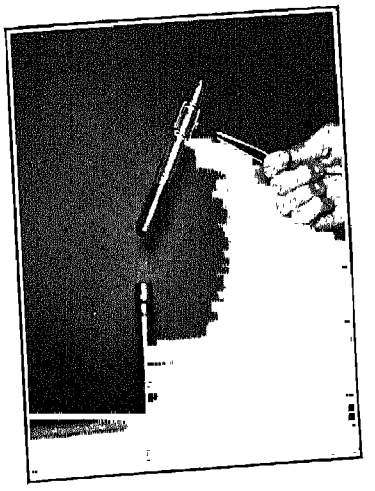
Esters are organic salts, and are formed by a process (esterification) which is very similar to neutralization. Since alcohols (acting as bases) and organic acids are very weak, their salts (esters) hydrolyze readily. In order to bring about such a reaction, sulfuric acid is used as a dehydrating agent, to take up the water as fast as it is formed. Many of the esters have a very pleasant odor. The fragrance of flowers and the flavor of fruits are due to this class of compounds.

A. ETHYL ALCOHOL, C_2H_5OH.

1. Pour 1 ml. of ethyl alcohol into a test tube. Now place the tube in a beaker of boiling water and remove the flame. Observe the comparative boiling points of the two liquids.
2. Ignite the fumes at the mouth of the tube. Observe the appearance of the alcohol flame.
3. Hold a clean, dry wide-mouth bottle down over the flame for a few moments. Observe the product of combustion which condenses on the sides of the bottle.
4. Add 5 ml. of limewater, then stopper and shake the bottle.
5. Iodoform Test for Ethyl Alcohol.
   a. Pour 1 ml. of ethyl alcohol, or any other liquid which you wish to test, into a test tube. Add 5 ml. of iodine-potassium iodide solution.
   c. Slowly add sodium hydroxide solution, drop by drop, until the color changes from dark brown to yellow.
   d. Cautiously smell at the mouth of the tube. The distinctive odor of iodoform, CHI_3, indicates a positive test for ethyl alcohol.

B. ETHYL ACETATE, $CH_3COOC_2H_5$.

1. Pour 1 ml. of ethyl alcohol, 3 ml. of acetic acid, 30%, and 1 ml. of concentrated sulfuric acid into a test tube.
2. Gently heat the tube until the liquid begins to boil, then cautiously smell at the mouth of the tube.
3. Test for an Acetate.
   Repeat B-1 & 2, using 0.5 grams (1/8 teaspoon) of sodium acetate, or any other substance you wish to test, in place of acetic acid. The odor of ethyl acetate indicates a positive test.



C. AMYL ACETATE, $CH_3COOC_5H_{11}$.

1. Prepare amyl acetate as in B-1 & B-2, using 2 ml. of amyl alcohol instead of ethyl alcohol.
2. Test the odor of the ester at the mouth of the tube.

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D. METHYL SALICYLATE, $C_6H_4OHCOOCH_3$.

1. Prepare methyl salicylate by the same procedure, using 2 ml. of methyl alcohol, 1 gram (¼ teaspoon) of salicylic acid, and 3 drops of sulfuric acid.
2. Test the odor of this ester.

E. ETHYL BUTYRATE, $CH_3CH_2CH_2COOC_2H_5$.

1. Prepare ethyl butyrate by the same procedure, using 1 ml. of each of the appropriate reagents.
2. Test the odor of this ester.

F. OBSERVATIONS.

1. Which class of inorganic compounds is similar in formula to the alcohols? . . . . . _____
2. Which class of inorganic compounds corresponds to the esters? _____
3. Name one general characteristic of the salts of weak acids and weak bases. . . . . _____
4. Compare the boiling points of alcohol and water. _____
5. Describe the appearance of the alcohol flame. . . . . _____
6. What happened in A-3? . . . _____
7. What happened in A-4? . . . _____
8. What does this prove? . . . _____
9. Write an equation for the reaction which occurred in A-2. . _____ + _____ → _____ + _____
10. Describe the odor of iodoform. . _____
11. Describe the odor of ethyl acetate _____
12. What is the function of sulfuric acid in this reaction? . . . . _____
13. Describe the odor of amyl acetate. . . . . _____
14. Describe the odor of methyl salicylate. . . . . _____
15. Describe the odor of ethyl butyrate. . . . . _____
16. Suggest a purpose for which these esters might be used. . . . . _____
17. B-1: _____ + _____ → _____ + _____
18. C-1: _____ + _____ → _____ + _____
19. D-1: _____ + _____ → _____ + _____
20. E-1: _____ + _____ → _____ + _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 61

ALDEHYDES AND ETHERS

MATERIALS: Ethyl alcohol; methyl alcohol; Fehling's solution; sulfuric acid; solutions of ammonium hydroxide, formaldehyde (5%), potassium dichromate, silver nitrate, and sodium hydroxide.

APPARATUS: 3 test tubes; graduate; test-tube holder; burner.

Aldehydes, organic compounds which contain the CHO group, are formed by the partial oxidation of the alcohols. Formaldehyde, which is a gas at normal temperature, is the most important member of this class of compounds. Formalin, an excellent disinfectant, is a 40% solution of this gas in water. The aldehydes are used extensively in the manufacture of many very useful products. Formaldehyde is used in the manufacture of bakelite; benzaldehyde, C_6H_5CHO, occurs in almonds, and vanillin, C_7H_7CHO, is responsible for the flavor of vanilla.

Ethers, organic oxides, are formed when any of the alcohols lose water, as a result of being heated with concentrated sulfuric acid. Ethyl ether is the most familiar, as well as the most important, member of this class of compounds. It is perhaps the most extensively used anesthetic in existence. It is also an important solvent for fats, oils, and resins (gums).

A. FORMALDEHYDE, H•CHO.

1. Pour 1 ml. of methyl alcohol into a test tube, and carefully add 1 ml. of concentrated sulfuric acid. Now add 2 ml. of potassium dichromate solution, which serves as an oxidizing agent.
2. Gently heat the mixture nearly to boiling, remove the flame, and cautiously test the odor of the formaldehyde at the mouth of the tube.

B. ACETALDEHYDE, CH_3CHO.

1. Repeat "A", using ethyl alcohol in place of methyl alcohol.
2. Cautiously test the odor of acetaldehyde at the mouth of the tube.

C. FEHLING'S TEST FOR ALDHEYDES.

1. Pour 1 ml. of Fehling's solution, $Cu(OH)_2$, into a test tube, and add a few drops of formaldehyde, 5% solution.
2. Gently heat the tube just to boiling, and observe the color of the precipitate, Cu_2O, which is formed. The formation of this color with Fehling's solution serves as a positive test for aldehydes.

D. SILVER MIRROR TEST FOR ALDEHYDES.

1. Pour 1 ml. of silver nitrate solution into a test tube and add 1 drop of sodium hydroxide solution. Now add ammonium hydroxide solution, drop by drop and with shaking, until the precipitate just dissolves.
2. Add a few drops of formaldehyde solution, and gently heat the tube. Observe the deposit on the sides of the tube. This deposit with silver nitrate serves as a positive test for aldehydes.

E. ETHYL ETHER, $(C_2H_5)_2O$.

1. Pour 2 ml. of ethyl alcohol into a test tube. Now add 1 drop of concentrated sulfuric acid, shake the tube, and test the odor.
2. Continue adding the acid, drop by drop, until the characteristic odor of ether becomes quite pronounced.

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F. OBSERVATIONS.

1. How are aldehydes formed? . . _____

2. Describe the odor of formaldehyde, in A-2. . . . . _____

3. What is the function of potassium dichromate in this reaction? . . _____

4. Write an equation for the preparation of formaldehyde. . . . $CH_3OH + (O) \rightarrow \quad +$ _____

5. Describe the odor of acetaldehyde, formed in B-2. . . . . _____

6. Write an equation for the preparation of acetaldehyde. . . . _____ $+ (O) \rightarrow \quad +$ _____

7. What color is produced by Fehling's test for aldehydes? . . . _____

8. Write an equation for this reaction. _____ $+ \rightarrow H{\bullet}COOH + \quad +$ _____

9. What change occurs in the valence of the copper ions? . . _____

10. What is the name of this type of reaction? . . . . . _____

11. This shows that aldehydes are good -?- agents. . . . . _____

12. What happened in D-2? . . . _____

13. What change occurred in the valence of the silver ions? . . . _____

14. Which property of aldehydes is shown by this reaction? . . . _____

15. Ethers are organic -?- . . . _____

16. How are ethers formed? . . . _____

17. Describe the odor of ethyl ether (common ether), formed in E-2. _____

18. What is the function of sulfuric acid in this reaction? . . . . _____

19. Write an equation for the preparation of ethyl ether. . . . . $\xrightarrow{H_2SO_4} \quad +$ _____

20. Show how potassium dichromate combines with sulfuric acid to act as an oxidizing agent.

_____ $+ \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + \quad +$ _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 62

SOAP: ITS PREPARATION AND PROPERTIES

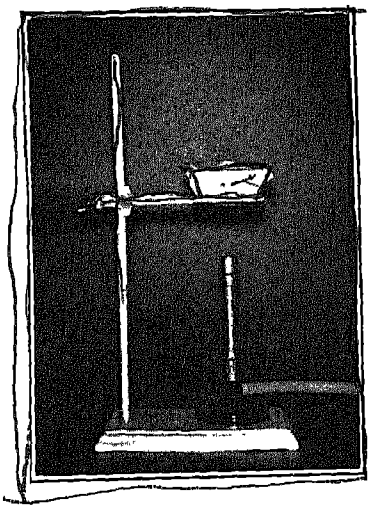
MATERIALS: Cottonseed oil, ethyl alcohol; kerosene; solution of sodium hydroxide (30%), sodium chloride (saturated), calcium chloride.

APPARATUS: Evaporating dish; 2 beakers; 4 test tubes; test-tube holder; test-tube rack; graduate; litmus paper; stirring rod; ring-stand and ring; wire gauze; asbestos square; burner; beam of light.

Fats and oils are mixtures of glyceryl, $C_3H_5^{+3}$, esters of stearic, palmitic, and oleic acids. Hard fats consist largely of the glyceryl esters, stearin and palmitin. Oily fats are composed chiefly of olein, $C_3H_5(C_{18}H_{33}O_2)_3$. When an alkali reacts with a fat, a soap and glycerin are produced. This process is called "saponification," a word which means "soap-making." Hard soaps are usually made by the reaction between hard fats and sodium hydroxide and liquid soaps are made from oily fats and potassium hydroxide. Alcohol is not ordinarily used in commercial soap making, but we will use it in this experiment as a solvent to bring the reacting materials into more intimate contact and thus to shorten the length of the reaction period.

A. SAPONIFICATION.

1. Assemble the apparatus.
2. Pour 10 ml. of cottonseed oil (glyceryl oleate),
   5 ml. of sodium hydroxide (30%), and
   10 ml. of ethyl alcohol into the evaporating dish.
3. Have an asbestos square at hand. Adjust the burner so as to produce a small flame. Stir the mixture constantly while the heat is being applied. Be sure the tip of the flame does not touch the bottom of the dish, and the reacting mixture does not boil. If the alcohol should catch fire, smother the flame by placing the asbestos square over the dish.
4. Continue the heating and stirring (about 10 minutes) until you can no longer detect the odor of alcohol, the globules of oil have disappeared and the mixture has become pasty.



B. SALTING-OUT.

1. Dilute the soap mixture, chiefly a mixture of sodium oleate and glycerin, with 30 ml. of boiling, distilled water. Stir until the consistency of the mixture becomes uniform.
2. Pour the warm soap mixture into a beaker containing 100 ml. of saturated sodium chloride solution. Stir the mixture thoroughly, and let it stand for a few minutes.
3. Skim off the soap into another beaker, and wash it with a little cold water. Pour off the water; press the soap into a cake and dry it between paper towels.

C. PROPERTIES.

1. Dissolve a piece of soap about the size of a pea, in 25 ml. of warm, distilled water.
2. Test the soap solution for the Tyndall effect.
3. Test the reaction of the soap solution with litmus paper.
4. Pour 10 ml. of the soap solution into each of 2 test tubes. Add nothing to the first tube, but add a few drops of calcium chloride solution to the second tube (forming hard water). Stopper and shake both tubes vigorously for a few moments, then compare the amount of suds produced in the two tubes.

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5-a. Pour 5 ml. of water and 1 ml. of kerosene into a test tube. Shake the tube vigorously for a few moments, then place it in the rack. Note the change which takes place in the mixture.

b. Now add 2 ml. of the soap solution. Shake the tube as before; place it in the rack and observe the results. Soap aids in removing oil and grease from the hands or clothing by forming this type of mixture with water which may easily be washed away.

D. OBSERVATIONS.

1. Write the glyceryl radical and indicate its valence. . . . . _____
2. What is the meaning of "saponification"? . . . . . _____
3. Which alkali is used in making hard soap? . . . . . _____
4. Name the two essential materials needed for saponification. . . _____
5. Why did we use alcohol in this experiment? . . . . . _____
6. Describe the appearance of the mixture formed in A-4. . . . _____
7. Give the full chemical name and formula for cottonseed oil. . . _____
8. Give the chemical name and formula for the soap formed in A-4. _____
9. What valuable by-product is formed during saponification? . _____
10. What is the appearance of the products formed in B-2? . . . _____
11. What did you prove by the results of C-2? . . . . . _____
12. What effect did the soap solution have upon litmus paper? . . _____
13. Which tube, in C-4, contained the most suds? . . . . . _____
14. Give the name and formula for the precipitate formed in the second tube, in C-4. . . . . _____
15. In washing, what commercial product should be dissolved in hard water BEFORE adding soap? _____
16. What happened in C-5a? . . . _____
17. What happened in C-5b? . . _____
18. Substances which act as soap did in C-5b, are called -?- . . . . _____
19. What is the name of the type of mixture produced in C-5b? . . _____
20. How does soap aid in removing oil and grease from clothing? . _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 63

PROTEINS

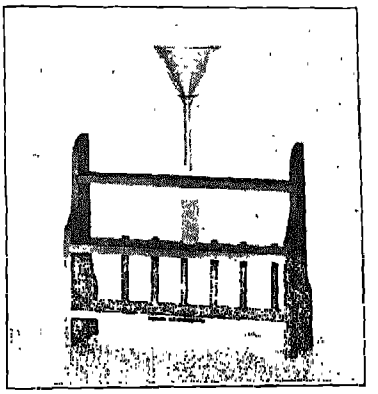
MATERIALS: Alcohol; ammonium hydroxide; nitric acid; tannic acid, 2%; egg white; solutions of egg white (10%), cupric sulfate, mercuric chloride, silver nitrate, and sodium hydroxide.

APPARATUS: 5 test tubes; funnel; filter paper; test-tube rack; test-tube holder; burner; beam of light source.

Proteins are constituents not only of all animal cells, but of many plant cells as well. They are particularly abundant in lean meat (myosin), and to a smaller extent in eggs (albumen), milk (casein), peas and beans (legumin), and flour (gluten). They are composed of the elements carbon, hydrogen, oxygen, nitrogen, and certain other elements which give them their distinguishing characteristics. During digestion, the proteins are hydrolyzed (broken down) into simpler, soluble compounds (amino acids) which readily pass through the intestine walls and are absorbed by the blood stream. Proteins are of the utmost importance to the body for they are used in building our own body tissues. In this experiment we will examine the properties of albumen (egg white), a typical protein.

A. NATURE OF PROTEINS.

1. Filter 10 ml. of egg white solution into a test tube. Proceed with "B" while you are waiting for the process to be completed.
2. Pass a beam of light through the filtrate.
3. Stopper and shake the tube vigorously. Note the results.



B. TYPICAL REACTIONS.

1-a. Gently heat a test tube containing 3 ml. of egg white solution.
b. Observe the effect of heat on proteins.

2-a. Pour 1 ml. of undiluted egg white into a test tube, and add 2 ml. of alcohol. Shake the tube with a gentle to-and-fro motion.
b. Observe the effect of alcohol on proteins.

3-a. Pour 2 ml. of egg white solution into a test tube. Now hold the tube up to the light and add 1 or 2 drops of tannic acid solution.
b. Observe the effect of organic acids on proteins. Tannic acid is used to coagulate the body juices on severe burns, and (as tea) to strengthen weak stomachs; that is, to prevent vomiting.

4-a. Arrange 3 test tubes in the rack, and add 2 ml. of egg white solution and 1 drop of sodium hydroxide solution to each of the tubes. Mix the reagents by gently shaking the tube.
b. Add 1 drop of cupric sulfate solution to the first tube, mercuric chloride solution to the second tube, and silver nitrate solution to the third tube.
c. Observe the effect of the salts of heavy metals on proteins. These compounds are used as germicides and fungicides.

C. TEST FOR PROTEINS.

1. NITRIC ACID (XANTHOPROTEIN) TEST.
   a. Pour 1 ml. of undiluted egg white into a test tube and add 1 ml. of nitric acid. Heat the tube gently for a few moments, and observe the color change.
2. BIURET TEST.
   a. Pour 3 ml. of egg white solution into a test tube and add 1 ml. of sodium hydroxide solution and 1 drop of cupric sulfate solution.
   b. Observe the mixture for a few moments, and note the color change.

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D. OBSERVATIONS.

1. Name the four elements which are always present in proteins. _____
2. What use does our body make of proteins? _____
3. What did you prove by A-1? _____
4. What happened in A-2? _____
5. What happened in A-3? _____
6. What did we prove in "A," about the nature of proteins? _____
7. What happened in B-1a? _____
8. What is the effect of heat on proteins? _____
9. What happened in B-2a? _____
10. What is the effect of alcohol on proteins? _____
11. What does this suggest about the use of alcoholic beverages? _____
12. What happened in B-3a? _____
13. What is the effect of organic acids on proteins? _____
14. Name one use of tannic acid. _____
15. What happened in B-4b? _____
16. What is the effect of the salts of the heavy metals on proteins? _____
17. Tell one use for the salts of the heavy metals. _____
18. What color change is produced by nitric acid on proteins? _____
19. What color change is produced by the subsequent use of ammonium hydroxide on proteins? _____
20. What color is produced by the Biuret test for proteins? _____

DATE..... PERIOD..... NAME.....

EXPERIMENT 64

TESTS FOR THE NUTRIENTS IN FOODS

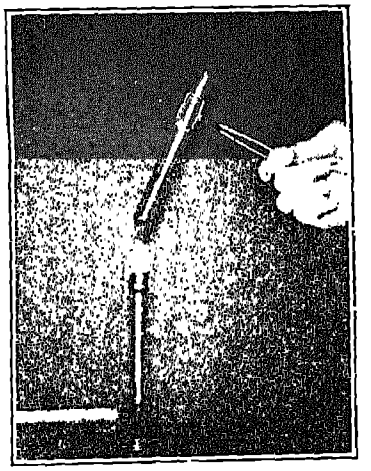
MATERIALS: Nitric acid; ammonium hydroxide; ether; iodine test solution; Fehling's solution; potato; apple; cooked egg white; cooked egg yolk; raisins; bread; cheese; peanut butter; banana; corn meal.

APPARATUS: 5 test tubes; beaker, 400 ml.; watch glass; test-tube rack; test-tube holder; filter paper; stirring rod; burner.

In all of the different kinds of food which are available, there are only three kinds of nutrients: carbohydrates, fats, and proteins. Our bodies need fairly definite amounts of each of these classes of nutrients each day. The carbohydrates and fats are needed to provide heat to maintain our body temperature, and energy for work and play. Proteins are needed as raw materials out of which new tissues are made (growth), and for the repair of old tissues. In addition to these nutrients, the body needs water, minerals, and vitamins. These are commonly called "body regulators," and are taken into the body along with the nutrients as a part of the food we eat. For best results in the following tests, except "D," the food samples should either be ground, or as scrapings, shavings, or thin slices.

A. STARCH.

1. Pour about ¼ teaspoon (or 2 ml.) of freshly scraped potato into a test tube containing 10 ml. of water.
2. Gently boil the mixture for at least 1 minute, then cool the tube in running water, or by placing it into a beaker of cold water.
3. Either pour off the liquid so the sediment remains behind (decant), or filter the liquid into another tube.
4. Add 1 drop, not more, of iodine test solution, and stir the mixture. This color with iodine serves as a positive test for starch.



B. SUGAR.

1. Pour about ¼ teaspoon (or 2 ml.) of freshly scraped apple into a test tube containing 5 ml. of Fehling's solution (equal parts of solutions "A" and "B").
2. Heat the tube and let the mixture boil gently for a few moments. This color with Fehling's solution serves as a positive test for simple sugars (monosaccharides).

C. FATS.

1. Pour about ¼ teaspoon (or 2 ml.) of bread crumbs into a test tube, and add 2 ml. of ether. Shake the tube with a to-and-fro motion for a few moments, then place the tube in the rack.
2. When the solid particles have settled, carefully pour the clear liquid into a scrupulously clean watch glass. Now place the watch glass on the window sill or under the hood while the solvent evaporates.
3. The greasy residue which remains on the watch glass is the fats which were dissolved from the bread.
4. Place the residue, from C-3, compactly on a piece of writing paper. Warm the paper for a few moments, or until the grease melts. Now remove the residue, and hold the paper up to the light. This translucent spot is another test for fats. You can test some foods, such as peanut butter, for fats by simply pressing a sample of the food on a piece of glazed paper. A translucent spot will appear, when the food is scraped off, only if a high percentage of fats are present.

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D. PROTEIN.

1. Use a clean, dry stirring rod to place a drop of concentrated nitric acid on a small piece of cooked (hard boiled) egg white. This color with nitric acid serves as a positive test for protein.
2. Wash the piece of egg white. Now place a drop of ammonium hydroxide on the spot where the acid was previously applied. This color with ammonium hydroxide is a further test for protein.

E. OBSERVATIONS.

1. What is the function of carbohydrates? . . . . . _____
2. What is the physiological function of fats? . . . . . _____
3. For what purpose does the body use proteins? . . . . . _____
4. What other food components does the body require? . . . . . _____
5. What reagent is used when testing for starch? . . . . . _____
6. What color indicates the presence of starch? . . . . . _____
7. What reagent is used when testing for sugars? . . . . . _____
8. What color indicates the presence of sugar? . . . . . _____
9. D-1: Protein + Nitric acid = _____ color.
10. D-2: Protein + HNO_3 + NH_4OH = _____ color.

Test as many of these foods for the nutrients as time will permit.

	Food	Starch	Sugar	Fat	Protein
11.	Potato				
12.	Apple				
13.	Bread				
14.	Egg white, cooked				
15.	Banana				
16.	Raisins				
17.	Cheese				
18.	Peanut butter				
19.	Egg yolk, cooked				
20.	Corn meal				

SOLUBILITY TABLE

	Acetate	Borate	Bromide	Carbonate	Chlorate	Chloride	Chromate	Ferricyanide	Ferrocyanide	Hydroxide	Iodide	Nitrate	Oxide	Phosphate	Sulfate	Sulfide
Aluminum	S	I	S		S	S			s	I	S	S	I	I	S	I
Ammonium	S	S	S	S	S	S	S	S	S	S	S	S		S	S	S
Antimony			s			s	I				s		I	s	s	I
Barium	S	I	S	I	S	S	I	s	s	S	S	S	S	I	I	S
Bismuth	S	I	s	I	S	s	I		s	I	I	S	I	I	S	I
Cadmium	S	s	S	I	S	S	I	I		I	S	S	I	I	S	I
Calcium	S	s	S	I	S	S	s	S	S	s	S	S	s	I	I	S
Chromium	S	I	S		S	S	I			I	S	S	I	I	S	I
Cobalt	S	I	S	I	S	S	I	I	I	I	S	S	I	I	S	I
Cupric	S	S	S	I	S	S	S	I	I	I	S	S	I	I	S	I
Ferric	S	I	S		S	S	S	S	I	I	S	S	I	I	S	I
Ferrous	S	I	S	I	S	S		I	I	I	S	S	I	I	S	I
Hydrogen	S	S	S		S	S		S	S	S	S	S	S	S	S	s
Lead	S	I	I	I	S	I	I	s	I	I	s	S	I	I	I	I
Magnesium	S	s	S	I	S	S	S	S	S	I	S	S	I	I	S	I
Manganese	S	I	S	I	S	S	S	I	I	I	S	S	I	I	S	I
Mercuric	S		S	I	S	S	s	I	I		I	S	I	I	S	I
Mercurous	s		I	I	S	I	I				I	S	I	I	s	I
Nickel	S	I	S	I	S	S	I	I	I	I	S	S	I	I	S	I
Potassium	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Silver	s	I	I	I	S	I	I	I	I		I	S	I	I	s	I
Sodium	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Stannic	S		S			S			I	I	S	s	I	I	S	I
Stannous	S	I	S		S	S	I		I	I	S		I	I	S	I
Strontium	S	I	S	I	S	S	s	S	S	I	S	S	s	I	I	S
Zinc	S	I	S	I	S	S	S	I	I	I	S	S	I	I	S	I

S = soluble in water s = slightly soluble in water I = insoluble in water

CHEMICAL CHECK LIST

(Suggested order list for 50 students)

Acid, acetic, glacial, 5 lbs.
Acid, butyric, 1 lb.
Acid, hydrochloric, 24 lbs.
Acid, nitric, 14 lbs.
Acid, oxalic, 1 lb.
Acid, salicylic, 1 lb.
Acid, sulfuric, 36 lbs.
Acid, tannic, 1 lb.
Albumen, egg, 1 lb.
Alcohol, amyl, 1 lb.
Alcohol, ethyl, 95%, 1 gal.
Alcohol, methyl, 1 gal.
Alizarin paste, 1 lb.
Aluminum powder, 1 lb.
Aluminum turnings, 1 lb.
Aluminum wire, No. 14, 1 lb.
Aluminum sulfate, 1 lb.
Ammonium aluminum sulfate, 1 lb.
Ammonium chloride, 1 lb.
Ammonium hydroxide, 8 lbs.
Ammonium molybdate, 1 lb.
Ammonium nitrate, 1 lb.
Ammonium sulfate, 1 lb.
Antimony metal, powder, 1 lb.
Antimony trichloride, 1 lb.
Arsenic metal, powder, 1 lb.
Arsenic tri-chloride, 1 lb.
Barium chloride, 1 lb.
Bismuth metal, lump, 1 lb.
Bismuth nitrate, 1 lb.
Bromine, 1 lb.
Cadmium nitrate, 1 lb.
Calcium carbide, 1 lb.
Calcium carbonate (marble chips), 5 lbs.
Calcium chloride, 5 lbs.
Calcium fluoride, 1 lb.
Calcium hydroxide, powder, 5 lbs.
Calcium oxide, lump, 1 lb.
Calcium phosphate, mono-, 1 lb.
Calcium sulfate (plaster of paris), 1 lb.
Candles, small, 50.
Carbon disulfide, 5 lbs.
Carbon tetrachloride, 5 lbs.
Charcoal, boneblack, 1 lb.
Charcoal, wood, sticks, 50.
Charcoal, wood, powder, 1 lb.
Chromium sulfate, 1 lb.
Cloth, muslin, white, 1 yd.
Cloth, linen, white, 1 yd.
Cloth, rayon, white, 1 yd.
Cloth, silk, white, 1 yd.
Cloth, wool, black, 1 yd.
Cobalt nitrate, 1 lb.
Congo red, 4 oz.
Copper metal, sheet, 1/32 in., 5 sq. ft.
Copper turnings, light, 1 lb.
Copper wire, bare, No. 14, 1 lb.
Cottonseed oil, 1 qt.
Cupric oxide, powder, 1 lb.
Cupric sulfate, fine, 5 lbs.
Ether, 1 lb.
Ferric ammonium citrate, 1 lb.
Ferric chloride, 1 lb.
Ferric oxide, 1 lb.
Ferrous sulfate, 1 lb.
Ferrous sulfide, lump, 1 lb.
Flour, wheat, white, 1 lb.
Formaldehyde, 1 lb.
Gelatin, granular, 1 lb.
Gold foil, 1 gram.
Glucose, white Karo syrup, 1 pt.
Hydroquinone, 1 lb.
Iodine, 4 oz.
Iron filings, fine, 1 lb.
Iron nails, 6d, 1 lb.
Iron tacks, No. 6, 4 oz.
Kerosene, 1 qt.
Lead metal, sheet, 1/32 in., 5 sq. ft.
Lead acetate, 1 lb.
Lead nitrate, 1 lb.
Lead oxide, Litharge, 1 lb.
Lead sulfide, 1 lb.
Lithium nitrate, 1 lb.
Litmus, blue, powder, 4 oz.
Magnesium metal, ribbon, 4 oz.
Magnesium oxide, 1 lb.
Malachite green, 4 oz.
Manganese dioxide, powder, 5 lbs.
Mercuric chloride, 1 lb.
Mercuric nitrate, 1 lb.
Mercuric oxide, 1 lb.
Mercury metal, 5 lbs.
Nickelous nitrate, 5 lbs.
Paraffin, 1 lb.
Pepper, 1 small box.
Phenolphthalein, 4 oz.
Phosphorus, red, 4 oz.
Phosphorus, yellow, 1 lb.
Photographic paper, 1⅞ x 2¾, 2 gross.
Potassium aluminum sulfate, 1 lb.
Potassium antimonyl tartrate, 1 lb.
Potassium bitartrate, 1 lb.

Potassium bromide, 1 lb.
Potassium chlorate, 5 lbs.
Potassium chloride, 1 lb.
Potassium chromate, 1 lb.
Potassium cyanide, 1 lb.
Potassium dichromate, 1 lb.
Potassium ferricyanide, 1 lb.
Potassium ferrocyanide, 1 lb.
Potassium hydroxide, 1 lb.
Potassium iodide, 1 lb.
Potassium nitrate, 1 lb.
Potassium oxalate, 1 lb.
Potassium permanganate, 1 lb.
Potassium sulfocyanide, 1 lb.
Silicon dioxide (sand), 1 lb.
Silver nitrate, 4 oz.
Soap chips, 1 small package.
Soda lime, 1 lb.
Sodium metal, 4 oz.
Sodium acetate, anhydrous, 1 lb.
Sodium bicarbonate, 1 lb.
Sodium carbonate, 5 lbs.
Sodium chloride, coarse, 25 lbs.
Sodium chloride, fine, 5 lbs.
Sodium hydroxide, pellets, 10 lbs.
Sodium nitrate, 5 lbs.
Sodium nitrite, 5 lbs.
Sodium phosphate, di-, 1 lb.
Sodium phosphate, tri-, 1 lb.
Sodium sulfate, 1 lb.
Sodium sulfide, 1 lb.
Sodium sulfite, anhydrous, 5 lbs.
Sodium tetraborate, 5 lbs.
Sodium thiosulfate, hypo, 10 lbs.
Stannous chloride, 1 lb.
Starch, corn, 1 lb.
Steel wool, 1 lb.
Strontium chloride, 1 lb.
Sucrose, brown cane sugar, 1 lb.
Sucrose, white cane sugar, 1 lb.
Sulfur, flowers, 1 lb.
Sulfur, roll, lump, 5 lbs.
Tin metal, granular, 20 mesh, 1 lb.
Vinegar, 1 qt.
Wood splints, 10 pkg.
Zinc metal, sheet, 1/32 in., 5 sq. ft.
Zinc, dust, 5 lbs.
Zinc, granular, 20 mesh, 10 lbs.
Zinc nitrate, 1 lb.

INDIVIDUAL APPARATUS

1 Asbestos square, 5 in.
1 Beaker, Pyrex, 50 ml.
1 Beaker, Pyrex, 100 ml.
1 Beaker, Pyrex, 150 ml.
1 Beaker, Pyrex, 250 ml.
1 Beaker, Pyrex, 400 ml.
1 Blowpipe, brass, 10 in.
1 Charcoal block, 4 x 1 x ¾ in.
1 Crucible, No. 0, with cover.
1 Deflagrating spoon.
1 Evaporating dish, No. 0.
1 File, triangular, 5 in.
1 Filter paper, 13 cm., pkg.
1 Flask, boiling, Pyrex, 250 ml.
1 Funnel, glass, 65 mm.
1 Graduated cylinder, 25 ml.
2 Glass tubing, 6 mm., 1 ft. length.
2 Litmus paper, (red and blue) pkg.
1 Medicine dropper.
1 Rubber tubing, 3/16 in., 2 ft.
1 Set measuring spoons.
1 Stirring rod, solid glass, 7 in.
6 Test tubes, Pyrex, 18 x 150 mm.
1 Thistle tube, 30 cm.
1 Watch glass, 4 in.
1 Wire gauze, 5 in.

DESK APPARATUS

1 Bottle, reagent, NH_4OH, 250 ml.
1 Bottle, reagent, HCl, 250 ml.
1 Bottle, reagent, HNO_3, 250 ml.
1 Bottle, reagent, NaOH, 250 ml.
1 Bottle, reagent, H_2SO_4, 250 ml.
4 Bottles, wide-mouth, 250 ml.
1 Bunsen burner.
1 Burner tubing, 5/16 in., 2 ft.
4 Glass plates, 2 in. x 2 in.
2 Glass plates, Cobalt-blue, 4 in.
1 Mortar and pestle.
1 Pneumatic trough.
1 Ring-stand, with 3 in. ring.
10 Rubber stoppers:
- 2 No. 1, solid.
- 2 No. 1, 1-hole.
- 1 No. 4, solid.
- 1 No. 4, 1-hole.
- 1 No. 6, solid.
- 3 No. 6, 2-hole.

1 Test-tube brush.
1 Test-tube clamp.
1 Test-tube holder.
1 Test-tube rack.
1 Tongs, laboratory.
1 Triangle, pipestem.

SUGGESTED SOLUTION CONCENTRATIONS

Acid, acetic: 30%; 1.35%.
Acid, butyric: Concentrated.
Acid, hydrochloric: Concentrated; 1%.
Acid, nitric: Concentrated.
Acid, oxalic: 5%.
Acid, sulfuric: Concentrated.
Acid, tannic: 2%; 0.1%.
Alizarin paste: Dilute 1 : 20.
Aluminum sulfate: 5%.
Ammonium hydroxide: Concentrated; 25%.
Ammonium molybdate: Dissolve 30 grams of ammonium molybdate in 200 ml. of distilled water; and add 10 ml. of ammonium hydroxide. Slowly add this solution, with stirring, to 200 ml. of 35% nitric acid. Let settle for several days; then filter or decant.
Antimony trichloride: 1 : 1, slightly acidified with hydrochloric acid.
Aqua regia: 1 part HNO_3 to 3 parts HCl.
Arsenic chloride: 1 : 1, slightly acidified with hydrochloric acid.
Barium chloride: 10%.
Bismuth nitrate: 10%.
Bromine water: saturated solution.
Cadmium nitrate: 10%.
Calcium chloride: 2%.
Calcium hydroxide (Limewater): Saturated solution. Filter or decant.
Chlorine water: Saturated solution.
Congo red: Dissolve 1 gram of Congo red, 5 grams of sodium carbonate, and 10 grams of sodium sulfate in 1 liter of water.
Cupric sulfate: 7%. (Also serves as Fehling's solution "A.")
Developer: Dissolve 5.8 gms. of hydroquinone, 19 gms. of anhydrous sodium sulfite, and 38 gms. of anhydrous sodium carbonate successively in 500 ml. distilled water. Keep in an amber bottle.
Fehling's solution "A": 7% cupric sulfate solution.
Fehling's solution "B": 35% sodium potassium tartrate in a 10% sodium hydroxide solution.
Ferric ammonium citrate: 10%.
Ferric chloride: 2%, slightly acidified with hydrochloric acid.
Ferrous sulfate: 2%, in a 1% solution of ammonium sulfate. Acidified with sulfuric acid.
Formaldehyde: 5%.
Glucose (Corn syrup or Karo): 5%.
Gold chloride: Dissolve 1 sheet of gold foil in 8 ml. of aqua regia. Dilute the resulting solution to 200 ml. with distilled water.
Javelle water: Mix equal volumes of 48% sodium carbonate and 12% calcium hypochlorite solution. Let it settle; then decant. Or, use "Clorox" or "Purex," diluted 1 : 20.
Iodine Test Solution (Iodine-potassium iodide solution): 2% iodine in a 4% potassium iodide solution.
Iodine, Tincture of: 7% iodine in a 5% alcoholic (95%) potassium iodide solution.
Lead acetate: 10%.
Lead nitrate: 10%.
Litmus solution: Dissolve a sufficient number of the cubes in water to impart a deep color.
Malachite green: 0.05%.
Mercuric chloride: 2%.
Mercuric nitrate: 5%.
Phenolphthalein: 1% in 50% alcohol.
Potassium antimonyl tartrate: 0.1%.
Potassium bromide: 5%.
Potassium chromate: 5%.
Potassium cyanide: 2%.
Potassium dichromate: 5%.
Potassium ferricyanide: 5%, freshly prepared.
Potassium ferrocyanide: 5%.
Potassium hydroxide: 10%.
Potassium iodide: 5%.
Potassium permanganate: 2%.
Potassium sulfocyanide: 5%.
Silver nitrate: 2%.
Soap solution: Dilute liquid hand soap 1 : 5 with distilled water.
Sodium acetate: 10%.
Sodium carbonate: Saturated; 5%.
Sodium chloride: Saturated; 5%.
Sodium hydroxide: 10%; 30%.
Sodium phosphate, tri-: 10%.
Sodium potassium tartrate: 2%.
Sodium sulfide: 5%.
Sodium tetraborate: 10%.
Sodium thiosulfate: 25%.
Stannous chloride: 5%. Add a few pieces of tin and a little HCl to prevent oxidation.
Starch solution: Make a 0.5% solution of soluble starch in cold water. Boil for a few minutes. Let cool; then filter.
Sucrose: (brown sugar): 5%.
Zinc nitrate: 5%.

ENGLISH - METRIC MEASUREMENT EQUIVALENTS

LENGTH

1 inch (in.)	=	2.54	cm.						
1 foot (ft.)	=	30.48	cm.	=	0.3048	m.			
1 yard (yd.)	=	91.44	cm.	=	0.9144	m.			
1 mile (mi.)	=	5280.	ft.	=	1760.	yd.	=	1.61	km.
1 millimeter (mm.)	=	0.1	cm.	=	0.001	m.	=	0.03937	in.
1 centimeter (cm.)	=	10.	mm.	=	0.01	m.	=	0.3937	in.
1 decimeter (dm.)	=	100.	mm.	=	0.1	m.	=	3.937	in.
1 meter (m.)	=	100.	cm.	=	39.37	in.	=	3.28	ft.
1 kilometer (km.)	=	1000.	m.	=	3281.	ft.	=	0.6214	mi.

AREA

1 square centimeter (sq. cm.)	=	0.155	sq. in.		
1 square meter (sq. m.)	=	10.76	sq. ft.	=	1.196 sq. yd.
1 square inch (sq. in.)	=	6.45	sq. cm.		
1 square foot (sq. ft.)	=	929.	sq. cm.		

VOLUME

1 cubic centimeter (cc.)	=	1	milliliter (ml.)						
1 milliliter (ml.)	=	0.061	cu. in.	=	20	drops			
1 cubic meter (cu. m.)	=	35.32	cu. ft.	=	1.31	cu. yd.			
1 liter (l.)	=	61.	cu. in.	=	1.06	quarts	=	1000	ml.
1 cubic inch (cu. in.)	=	16.4	ml.						
1 cubic foot (cu. ft.)	=	0.0282	cu. m.	=	28.3	l.	=	7.48	gal.
1 cubic yard (cu. yd.)	=	0.765	cu. m.	=	764.	l.	=	202	gal.
1 teaspoon (tsp.)	=	5	ml.						
1 tablespoon (tbsp.)	=	15	ml.						
1 cup	=	237	ml.						
1 ounce (fluid)	=	29.57	ml.						
1 quart (qt.)	=	946	ml.	=	0.946	liters			
1 gallon (gal.)	=	3.785	liters	=	231	cu. in.			

WEIGHT

1 gram (gm.)	=	0.03527	oz.						
1 kilogram (kg.)	=	1000	grams	=	2.2	pounds			
1 ounce (oz.)	=	28.35	grams	=	0.0625	pounds			
1 pound (lb.)	=	453.6	grams	=	16	ounces			
1 ton (T.)	=	2000	pounds	=	907.2	kilograms			
1 liter of water	=	2.2	pounds	=	1000	grams	=	1	kilogram
1 gallon of water	=	8.35	pounds	=	3.79	kg.			
1 cu. ft. of water	=	62.4	pounds	=	28.3	kg.			

PRESSURE

1 atmosphere	=	14.7	pounds per square inch
Standard Pressure	=	1033	grams per square centimeter
	=	760	millimeters of mercury
	=	76	centimeters of mercury
	=	30	inches of mercury
	=	14.7	pounds per square inch
	=	1	atmosphere

YEAR 19..... PERIOD..... NAME.....

STUDENT APPARATUS CHECK LIST

(Check the apparatus received, then return this sheet to the instructor)

Article	Size	Number received	Number returned	Number broken	Approx. price	Total
Beakers, Pyrex	50 ml.				.17	
Beakers, Pyrex	100 ml.				.18	
Beakers, Pyrex	150 ml.				.19	
Beakers, Pyrex	250 ml.				.20	
Beakers, Pyrex	400 ml.				.26	
Crucible	No. 0				.20	
Crucible cover	No. 0				.09	
Evaporating dish	No. 0				.22	
Filter paper, pkg.	13 cm.				.15	
Flask, boiling	250 ml.				.20	
Funnel, glass	65 mm.				.24	
Glass tubing, 1 ft.	6 mm.				.02	
Graduated cylinder	25 ml.				.30	
Litmus paper	Package				.05	
Medicine dropper					.03	
Matches, safety	Box				.01	
Platinum Wire, No. 28	35 mm.				.35	
Retort	125 ml.				.90	
Test tubes, Pyrex	18 x 150				.05	
Thistle tube	30 cm.				.15	
Watch glass	4 in.				.07	

INVENTORY: DESK EQUIPMENT

(Check the apparatus received, then return this sheet to the instructor)

Article	Size	Number received	Number returned	Number broken	Approx. price	Total
Asbestos square	5 in.				.02	
Blowpipe, brass	10 in.				.20	
Bottles, wide-mouth	250 ml.				.06	
Burner, Bunsen	6 in.				.75	
Burner tubing, rubber	5/16 in.				.20	
Burette clamp	Small				.40	
Charcoal block	4 x 1 x 3/4				.04	
Deflagrating spoon	Brass				.10	
File, triangular	5 in.				.13	
Glass plate, plain	2 x 2 in.				.01	
Glass plate, cobalt	4 x 4 in.				.10	
Mortar and pestle	250 ml.				.60	
Rubber stopper	1: solid				.02	
Rubber stopper	1: 1-hole				.02	
Rubber stopper	4: solid				.03	
Rubber stopper	4: 1-hole				.03	
Rubber stopper	6: solid				.04	
Rubber stopper	6: 2-hole				.04	
Rubber tubing, 1 ft.	3/16 in.				.05	
Spoons, measuring	Set				.10	
Stirring rod, glass	10 in.				.02	
Test-tube brush	10 in.				.08	
Test-tube clamp	4 3/4 in.				.05	
Test-tube rack	12-tube				.50	
Tongs, laboratory	7 in.				.25	
Triangle, pipestem	3 in.					

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